

# Metallurgical *and* Chemical Engineering

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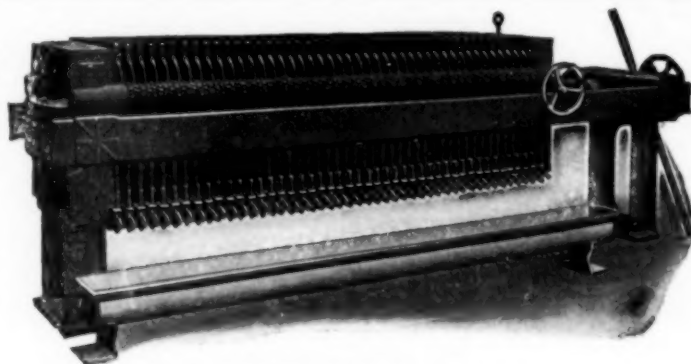
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# Metallurgical and Chemical Engineering

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## Aesop at Niagara Falls

A Sentimental Eagle and a Greedy Tiger lived on the bank of a great river, full of fish, and on the other side a Wise Beaver gnawed wood and dwelt at peace with his neighbors for a long time. One day, however, the Eagle and the Beaver disputed over the fish they caught, but at last agreed that for a time each should take a certain amount of fish from the river and so there was peace again.

The Tiger who hitherto had contented himself with other food, seeing that the Eagle was not taking all the fish which were his due, said:

"Behold, I also would eat fish."

Thus there arose a fierce fight between the Eagle and the Tiger; but the Beaver gnawed wood and said nothing.

After a time the Beaver said to himself:

"My foolish neighbors are busy fighting about the fish of which there is abundance in the river for all. My agreement with the Eagle is at an end, why should I not help myself?"

Whereupon, while the Sentimental Eagle and the Greedy Tiger fought, the Wise Beaver fell to catching all the fish he wanted.

*The crown of the wise is their riches:  
but the foolishness of fools is folly.*

## Keeping Posted

Another chapter has been written on the subject of volatilizing metals as chlorides, which of itself might not excite special comment were it not for the fact that it is almost identical with a similar chapter written ten years ago. There is no thought of charging plagiarism on the part of the second engineer, for in these days of wide publicity in technical matters it would be absurdly foolish to present another man's work as one's own, even after the lapse of a decade. The wonder is that the later investigator carried his work so far without making a search in the literature to see whether his ideas had been anticipated.

About fifteen years ago Messrs. Pohle and Croasdale observed the volatility of metallic chlorides, and as the result of laboratory experiments were encouraged to try the process on a larger scale. Within the next few years they erected a plant, tested many ores, acquired a vast amount of experience and accumulated many data. In 1903 Mr. Croasdale published an article on the subject, and presumably the metallurgical world was properly advised of the status of volatilization as a process for treating ores. Considering the time and money spent in experimentation, the results published by Mr. Croasdale represented the extent of our knowledge on the subject at that time.



Last year Mr. Ben Howe announced from Australia that he had discovered a new process which was going to be of great advantage in the treatment of ores that were refractory to known processes. His work resembled that of Pohle and Croasdale in almost every respect. The apparatus employed for volatilization and condensation, the degree of success attained and the cause for ultimate failure were similar to those of the earlier investigators. And finally, Mr. Howe left the process exactly where American metallurgists had left it ten years before, having spent a great amount of money in duplicating their work, and failing to condense or collect his products, just as they had.

The Australian work was an economic waste of time and money because it demonstrated only known facts.

The moral is plain: before a metallurgist pursues too far an idea that is new to him, let him consult the records which it is one of the functions of a technical journal to preserve. A literary research should precede elaborate experiment. If Mr. Howe had known of Croasdale's work, he might have been discouraged from trying the process or would have tried to improve on it. Had he elected the latter procedure he would have had an excellent starting point. It pays to keep posted.

### The Power Problem of Electrochemistry

The power cost is usually a very considerable item in the cost sheet of electrochemical processes—so much so that this consideration has influenced to a large extent the geographical location of electrochemical industries. The hydro-electrochemical plants of Niagara Falls and Norway are typical examples. But it would be wholly wrong to conclude that electrochemistry must rely on water-power. Water, steam, gas, and even oil, all have their possibilities, according to the requirements of the case and the location. For the case of a large electrolytic copper refinery the subject is admirably treated in the papers of Messrs. Addicks, Longwell and Newbury, reported elsewhere in this issue. But the power problem in electrochemistry is a much broader subject and it is for this reason that this broad general subject has been chosen for a symposium at the general meeting of the American Electrochemical Society, to be held in New York City from April 16 to 18. This should be an opportunity for a lively discussion.

### Steel Costs and Selling Prices

The more optimistic are now insistent that a new era has dawned in the sale of steel products. The selling and operating departments are actually to work in harmony. The sales department is expected to abandon its old policy of advancing prices by getting under them and instead to conduct its sales of products with reference to the cost of producing them. In the one case the general manager of sales consults the cost sheet furnished by the operating department. In the other case he consults the treasurer with reference to the possibility of floating more paper.

The operating man has always felt hurt that while he labors hard and incessantly to save a dime per ton in the cost of producing steel the sales agent carelessly

tosses away a dollar to get an order away from a competitor who scarcely needs such incentive to get back at sales agent No. 1 on the next inquiry that comes into the market. Of course, the sales agent's excuse is that a dime saved by improved manufacturing methods is permanent, applying on an indefinite number of tons, whereas the cut price is applicable only to the definite tonnage under negotiation. In practice, however, sales contracts for steel have been virtually guaranteed against decline, and thus the effects of a single cut have often proved far-reaching.

A natural law which is unfortunate from the viewpoint of selling methods in the past is that as the employment of a manufacturing plant increases the unit cost of production decreases. If a plant can produce steel at a cost of \$30 a ton when operating at 60 per cent of capacity, and at \$29 a ton when operating at 70 per cent, then it requires little computation to show that if the 60 per cent product has been sold at \$30 it is theoretically possible to sell another 10 per cent at only \$23 a ton and yet have the cost of the entire product equal to the average selling price. If the 10 per cent can be sold at \$25 instead of \$23 there is apparently an added profit to the mill in making the sale. In a declining market the trick would not work, for the cut price sale would endanger the previous sales made at the higher price, but in an advancing market there is a strong incentive to ignore the advances until full operation is reached.

The greatest friction between the sales and operating departments has come in periods of slack operation, when the sales department cuts prices to "meet the market" and calls upon the operating department to reduce its costs, at the very time when it is wrestling with the impossible problem of preventing the cost from actually rising through the reduced rate of operation. In lighter vein some superintendents have been urging the formation of an "operating men's union" collectively to resist the demands of the sales department and hold it to the basis of the operating costs being shown by the plant at the time the price on a given order is to be quoted. Should such a union succeed, we might have the interesting market spectacle of prices advancing as mills run out of orders and declining as they approach full operation.

Seriously, however, there is need of greater co-operation between the sales organization and the operating organization, and we hope the tendency towards such greater co-operation will grow. If generally practiced it will necessarily inure to the benefit of all.

### Custom Cyanide Mills

A recent venture in running a concentrating-cyaniding mill on a custom basis, in a district producing a wide variety of ores in comparatively small lots, calls attention to difficulties that may be encountered under such conditions. From a mechanical point of view no serious obstacles appear, for the different departments of the mill, such as concentrating, agitating, thickening, leaching or filtering, can be designed to meet the extreme conditions that may arise. Thus the



thickening capacity, for example, can be based on the requirements of the ore yielding the slime most difficult to handle; and so on through the other departments. At times this extreme capacity will not be needed, but it is available when required.

Considered from the chemical point of view, however, the difficulties begin to multiply. Unless an elaborate bedding system is provided, with a regular supply of different ores to make the bed, there will be no uniformity in the mill feed. A fifty-ton lot of sulphide ore full of acid or other cyanide may be followed by one requiring little or no protective alkali; and these in turn may be followed by two lots, one of which requires a two-pound cyanide solution while the other will yield its metal only to a five-pound solution. Some lots may require long periods of agitation, while from others the bulk of the precious metals may be dissolved before the agitator is reached. The slime from some ores may have a high settling rate, and thicken to a low-moisture content in decantation, whereas other slime may require filtration for economic treatment. All of these features make it difficult, if not impossible, to obtain uniform milling conditions.

The commercial side of the proposition also offers some obstacles. The schedule of rates must apply to all of the ores offered, whether they are desirable or otherwise; and a nice adjustment is required to have these rates high enough to protect the operator in handling the least desirable ores, and at the same time low enough to attract the ores that are easily treated and from which the most profit can be derived. If other competitive means of ore treatment are at hand, the rate question becomes more troublesome, for the most desirable ores may be diverted to competing buyers who can offer better rates. This will result in surfeiting our custom mill with the most refractory ores from which little profit is to be made.

The conditions described are probably extreme, but are none the less real. They call for the most painstaking preliminary examination before the mill is built, and the best engineering and business skill afterwards.

### The Government's Trust Program

Time has been good to the Washington administration in the matter of the great trust program. Not until now has it been brought squarely to face the duty of developing and enacting a program. Meanwhile the thought of the country has largely crystallized, the trusts, or the "malefactors of great wealth" or whoever they are, have become relatively tractable, and through the training practiced in the tariff and currency legislation the parliamentary body which our last Democratic president referred to as "having on his hands," the present executive could, if he were not far too discreet, refer to as having in his hands.

Viewed with reference to the turmoil and confusion which has raged about the "trust question" the dominant note of President Wilson's address to Congress is not the peace between government and business upon which the daily press has harped, for that we

had a right to expect; it is that the problem is to be attacked, not from the viewpoint of history, of what has occurred, of how the so-called "trusts" were put together, but from the viewpoint of what exists, what is private monopoly and what is not, and what is the conduct of great business organizations. It is being more and more frequently said nowadays that the Sherman law is better understood, is almost perfectly understood, but no understanding of that law can prevent the courts, in applying it in specific instances, to look largely to the method of formation of a "trust" thus tending to belittle the cogency of its present position and prospects. The talk at one time ran largely to the question whether an egg could be unscrambled, though some apparently wanted to end the uncertainty by eating it up. President Wilson's message does not run along such lines; it is eminently more practical in directing attention to conserving that which is to-day good, and destroying only that which is to-day bad.

The saneness and reasonableness of the administration's position may possibly be brought out well by the use of a little imagination. Let us conceive a man who can study things only by their genesis and see what a picture he might draw. In the decade of the nineties industry was full of secret agreements, "gentlemen's" agreements, associations, pools, all occasionally successful and all more or less unsuccessful at one time or another. Then came the promoter with Wall Street for the flotation of the securities he would create by buying out competitors, scrambling them, so to speak, and thus conducting the greatest of all conspiracies in restraint of trade, and obviously under the ban of the Sherman law, for years ago the court decided, in a Standard Oil case, that admitting that the separate entities brought together under a holding company had not previously been competitive, yet the formation of the holding company made the control more efficient and more easily administered, and was therefore illegal, even though there had been no competition which could directly be killed. A most lurid picture of what occurred years ago might easily have been drawn, and the viewpoint established of taking the genesis, not the present position and conduct of "big business" as the basis from which the trust problem should be attacked.

The president's message is not about a trust problem, but about a monopoly problem. It refers to what exists, and if it represents, as claimed, the crystallization of public sentiment, then the dissolution suits now in progress under the Sherman law have been an anachronism for some time past.

There lies no menace in the fact that many men will question the new freedom which the administration's program is claimed to promise, on the ground that there is no particular lack of freedom at present. Let the work be prosecuted to a finish. Those who criticize on the ground that there is little good for it to do can hardly at the same time insist that it will do harm. All admit that the removal of uncertainty is of prime importance, and that is clearly promised.

## Readers' Views and Comments

### Relative Thermal Conductivity of Silica and Clay Brick

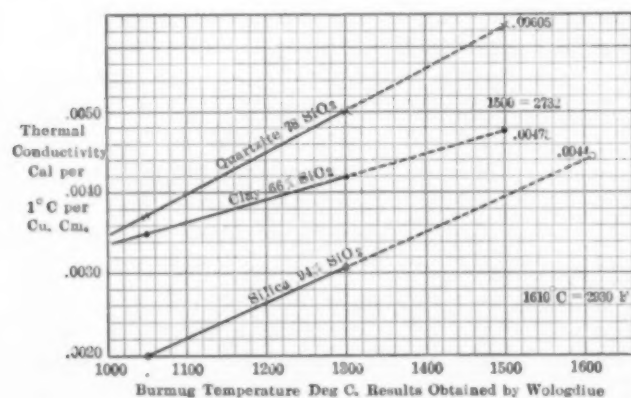
To the Editor of Metallurgical & Chemical Engineering:

SIR:—Reference has been made in THE METALLURGICAL AND CHEMICAL ENGINEERING and other publications during the past year to the heat conducting power of silica brick as compared to clay brick. In practically all cases it has been stated that silica bricks are less perfect conductors than clay bricks.

In the majority of cases this comparison has apparently been taken unquestioned from tests made by Wologdine and published in *Revue de Metallurgie*, June, 1909, and abstracted in METALLURGICAL AND CHEMICAL ENGINEERING of September, 1909. In this paper the following comparison appears:

Material	Approx. Analysis	Burning Temp., Deg. C.	Conductivity Cal. per 1° C. Diff. per Cu. Cm.
Clay brick	78% SiO <sub>2</sub> 18 Al <sub>2</sub> O <sub>3</sub>	1050	.0037
	3.3 Fe <sub>2</sub> O <sub>3</sub> .5 CaO	1300	.0050
Clay brick	66% SiO <sub>2</sub> 29 Al <sub>2</sub> O <sub>3</sub>	1050	.0035
	4 Fe <sub>2</sub> O <sub>3</sub> .5 CaO	1300	.0042
Silica brick	94% SiO <sub>2</sub> 1% Al <sub>2</sub> O <sub>3</sub>	1050	.0020
	2% Fe <sub>2</sub> O <sub>3</sub> 2% CaO	1300	.0031

These results are shown in the accompanying figure and the curves have been extended to the usual burning temperatures of the three materials. It will be observed that the conductivity of the silica brick burned at about 1600° C. is greater than that for clay as obtained by Wologdine, though somewhat less than the clay results at the usual burning temperature.



THERMAL CONDUCTIVITY OF CLAY BRICK AND SILICA BRICK AS FUNCTION OF BURNING TEMPERATURE

These results in themselves appear somewhat discordant, as it would be expected that the conductivity would vary at least in some regular way with the silica content.

While questioned, these figures are used by Havard in "Refractories and Furnaces" and by Hering in "Flow of Heat Through Bodies" in METALLURGICAL AND CHEMICAL ENGINEERING, December, 1911. In numerous other places these tests appear to have formed the basis for a comparison of the value of these two materials either as heat conductors or as heat insulators. (Compare Randolph "The Conduction of Heat," *General Electric Review*, 1913; Tone "Carborundum Refractories," METALLURGICAL AND CHEMICAL ENGINEERING, October, 1913.)

No doubt these data are correct comparatively for the materials tested, but the results show that the conductivity increases with the temperature of burn and

commercial silica brick are burned at a higher temperature than 1300° and at a temperature from 125° to 225° higher than that used for clay brick. Hence, while the results given may be correct for the materials tested, yet they are useless for the comparison of commercial American refractories.

Experience with the use of silica brick as compared with either clay or quartzite brick in by-product coke ovens, gas retorts, checker chambers and many other places has shown that silica bricks are appreciably better conductors than the other two materials. One set of published data shows this. Fitzgerald in "Experiments in Heat Insulation" (METALLURGICAL AND CHEMICAL ENGINEERING, May, 1912) shows that 550 watts will maintain a temperature of 660° C. within a small test furnace built of clay brick, while 730 watts are required when silica brick are used.

A carefully conducted series of tests which would give a fair comparison between the refractories in regular use in America would be of value. It is possible that some such data may be available in the files of some of the refractory manufacturers which could be published and would be of value to users of these materials.

S. M. MARSHALL.

Johnstown, Pa.

### The Induction Furnace for Steel Melting and Refining

To the Editor of Metallurgical & Chemical Engineering:

SIR:—In your issue of October, 1913, some "Induction Furnace Notes" were given by Mr. Joh. Härdén. In these notes he stated the efficiency of a 2-ton furnace to be 63.8 per cent. In your December issue, however, he corrected this to be 67.1 per cent, assuming that in the first calculation he had made a mistake by using 636 instead of 606 units as the average consumption of electric energy during a run of 606 hours. On the left side of page 561 the time is, however, stated to be 606 hours and the amount of average energy used during said 606 hours to be 636 units. These values appear to be right and Mr. Härdén has probably got the figures mixed up in some way in his latter notes.

The efficiency is more likely to be only 63.8 per cent for a 2-ton furnace as the total efficiency of the 10-ton induction furnaces at the Krupp works is not more than 72 per cent, according to the statement in an advertisement on page 48 of the issue of January, 1913, of your paper. The difference in efficiency of a 2-ton and a 10-ton furnace should certainly be more than some 5 per cent, and this makes it probable that the lower value is the right one for the 2-ton unit. It would be interesting if Mr. Härdén would kindly explain more clearly why the efficiency is not 63.8 per cent as originally was stated.

The opinions about the merits of the induction furnace seem to be rather diverging among metallurgical engineers. In the issue of your journal of November, 1911, Mr. Joh. Härdén makes the statement that "it is well known that very little refining as regards sulphur and phosphorus can be effected in the induction furnace . . ." and proceeds to give some very good reasons for the alleged deficiency of the induction furnace in this respect. This statement is quite interesting as it emanates from a metallurgical engineer of high standing and closely associated with the induction furnace interests in Great Britain.



Contrary to said opinion are, however, some remarks by Mr. C. H. vom Baur in the January number of your journal for 1912, stating that he witnessed a 10-ton induction furnace refining basic Bessemer metal with phosphorus 0.08 and sulphur 0.09, getting *P* and *S* down to 0.008 and sometimes to traces and at the same time achieving a high degree of deoxidation.

There is entirely too much discrepancy between the two statements and this fact is certainly worth a careful consideration when deciding whether to install an induction furnace or a modern arc furnace.

In your issue of November, 1911, page 573, Mr. T. D. Robertson also states that the induction furnaces are difficult to use for refining purposes.

The induction furnaces admittedly possess some beautiful features but also have too many practical drawbacks to become ever general favorites or even to enable them to hold the place they have been occupying in the electrometallurgical industry. It would greatly benefit the development of the electric refining methods if an unprejudiced discussion could be started regarding the real and imaginary merits of all the different systems of electric furnaces now offered to the trade.

IVAR RENNERFELT.

Stockholm, Sweden.

### Hydrometallurgy—Joys of Its Practice, Woes of Its Theory

To the Editor of Metallurgical and Chemical Engineering:

Sir:—In reply to Mr. Bleecker's communication in your January issue, I will endeavor to establish my former statement that he is ignorant of the subject of dry chlorination. I shall do this impersonally, and mainly because Mr. Bleecker represents in this instance a type of engineer who presumes to pass opinion on matters of which he has little or no knowledge. Ofttimes, through failure of capital to recognize this kind of incompetency, the development of schemes is either undertaken without warrant or unduly delayed. The opinion of this type of engineer is a menace to any industry, whether he be for or against any particular proposal. The fact very often overlooked is that the absorption of knowledge in any one branch of a profession does not of itself qualify one to pass upon matters in every other branch.

Sour grapes? No! Dry chlorination has suffered from over-indorsement. Some of the most favorable indorsements have been based on conclusions equally as absurd as those assumed by Mr. Bleecker against it. I specifically object to incorrect or unwarranted assumptions, whether they be for or against dry chlorination or any other scheme.

A sub-type of engineer equally as dangerous is he who tries to cover his ignorance by shrug of shoulder or a silly smile. In such a case ignorance is accompanied by cowardice.

It was with no hope of convincing the agnostics or the advocates of other methods of ore treatment that dry chlorination will solve the complex ore problem that I threw down the challenge, but rather to bring out into the open if possible those who have selected a dark alley in which to waylay their victim. Certainly a revised code of ethics is needed in our profession, or a better understanding on the part of a few of the code now existing.

Mr. Bleecker excuses his ignorance on the ground that his knowledge was derived from published articles. This will not stand in view of the fact that on June 28, 1911, Mr. Bleecker was invited by me to accompany a party of engineers on the following day

to Georgetown to inspect the plant under construction, receive a detailed statement of the proposed *modus operandi*, and go the limit of honest criticism.

Of the articles referred to by Mr. Bleecker, only that of Mr. Wolf was published with my knowledge, and the statements are correct as far as they go. A more detailed statement at that time was deemed unwise on account of the status of patent applications. The "incorrectness and absurdity" mentioned by Mr. Bleecker result solely from the unwarranted assumptions which he makes in connection with the published statements.

For convenience and brevity in making this reply, I have numbered the paragraphs of Mr. Bleecker's communication from 1 to 39 inclusive, and will refer to them by number. Such other items as I consider worthy of attention, and which are not touched on here, are covered in my article on dry chlorination elsewhere in this issue.

14. Certainly Mr. Bleecker's acknowledgments that the cycle of reactions is complete, the chemistry perfect, and the substitution process faultless are facts in favor of the process. Unless these initial conditions existed it would be folly to propose the scheme.

17. Apparently Mr. Bleecker has never made a test for extraction by dry chlorination. I have yet to find a sulphide ore which would not yield its values to any extent desired by the method referred to. As for the handling of chlorine gas, Mr. Bleecker need go no farther than Niagara Falls to enlighten himself on this subject. Referring to materials of construction, there is no need for unlimited choice of such materials for tanks, agitators, and filter presses. Impregnated wood answers every requirement, and asbestos filter cloths are equally as serviceable for filtering the solutions occurring in this process as canvas is in the filtration of non-corrosive solutions.

25-26-27. I wish to confirm Mr. Wolf's statement as to the recovery of from 14.2 to 14.4 pounds of zinc per horsepower-day. I have, however, been unable to ascertain where Mr. Bleecker gets the figure of 3.5 for voltage, as used in his calculations. This voltage was provided to take care of both internal and external resistance, and might justly have been mentioned as the voltage employed. In other words, a total voltage of 75 on a series of 20 cells would be a factor in determining the cost of electrolysis, but certainly should not be involved in determining cell efficiency as Mr. Bleecker has applied it. The voltage required for internal resistance of each cell did average 3.1. Therefore the theoretical quantity of zinc deposited per horsepower-day at 3.1 volts is

$$\frac{746 \times 24 \times 1.2}{3.1 \times 453.5} = 15.3 \text{ lb.}$$

The ampere-hour efficiency of the cells is  $\frac{14.3}{15.3} =$

93.4%, which is not unusual in other forms of cells.

The watt-hour efficiency is 66.4%, thus

$$\frac{746 \times 24 \times 1.2}{2.2 \times 453.5} = 21.53 \quad \frac{14.3}{21.53} = 66.4\%$$

Can Mr. Bleecker now figure how much "heat" we derive from "calcium sulphate"?

31. Mr. Bleecker is correct. The entire cost of grinding, chloridizing, "bottling," etc., can be done for \$1.86 per ton, including the cost of electric power for these operations.

34. Silica, lime, iron, magnesia or arsenic are not factors. The chlorides of metals not sought are employed to chloridize the metals which it is desired to recover from the ore.



37. I have no knowledge of calcium sulphate causing any difficulty. Its presence in solutions has been observed only from slight deposits in first-stage evaporators, but not in the fused zinc chloride.

Mr. Skinner's communication certainly favors the further development of dry chlorination, if for no other purpose than to handle successfully the finely disseminated ores, in the treatment of which there is no competition. That is just the application for which the process is urged as a starter, although I am convinced of its broader application.

The advocates of mechanical concentration can find little solace in the results reported in your January issue on the concentration of the complex sulphide ores at the Mary Murphy mine. I understand that the treatment of this ore is conducted under the most favorable conditions of expert direction and up-to-date appliances, and yet the results are not all that could be desired. It is just such instances which have discouraged even an attempt to apply mechanical concentration to complex ores. It is about time mechanical concentration was passing through a period of refinement; and even if we have competent metallurgists to usher in this period of improved mechanical methods, we can be equally certain that hydrometallurgists will respond to the demands of their profession.

Dry chlorination has been recognized far more favorably by Mr. Skinner than I had expected, but even to win this favor it has not modified its early claims, although it has been willing, for sake of argument, to have its merits determined by using a factor of 2 on its estimated cost of operation. I can understand how those who are actively engaged in mechanical concentration do not find time to consider seriously the developments in other lines. Many have gone to sleep at the switch from sheer exhaustion in meeting the pressing demands of their own work; others find time to make only superficial examination of the claims of other processes, and consequently fall into error.

Denver, Colo.

JOHN L. MALM.

### Chemistry of Salt Water Cement

To the Editor of Metallurgical and Chemical Engineering:

SIR:—To my article on the "Chemistry of Salt Water Cement," published on pages 26 to 30 of your January issue, I wish to make a few additions so as to make them a part and parcel of my original article.

After the fourth line of the right column of page 27, the following insertion should be made:

"It has been authoritatively stated that the Italians were the first to make use of pozzolana, trass, or tuff—together with the admixture of a larger proportion of cement—for making concrete that was to stand in sea water more impermeable and more resistant; both mechanically and chemically. Since then the practice of thus treating concrete has become very popular in Germany and Holland. In Italy, where pozzolana is so abundant, the practice of using only Portland cement, sand, gravel or stone for sea water concrete was looked upon with suspicion. Though the cost of cement is high in Italy, this feeling of doubt is based upon the dangers of decomposition of cement in sea water unless pozzolana was used.

"The successful use of pozzolana by the Italians and the French is no doubt accounted for by the exceptionally good quality of Mediterranean lime. While lime concrete has been used with marked success in the dock work of England, in her sea structures, that is, where the concrete is exposed to the full force of

the waves and pounding action of the seas, it had not proven to be a success.

"The excellent results obtained from using pozzolana concrete in sea water structures are shown by the mole of Nero, at Porto d'Anzio, or of Hadrian, near Bari; structures still in existence, though built 17 centuries ago.

"In explanation of the long life of these two structures, Prof. Luigi Luiggi, the noted Italian Engineer, has said: 'Pozzolana contained a large amount of free gelatinous silica ready to combine with the free lime that unfortunately was always present in Portland cement—even the best. Thus, when Pozzolana was added in mixing Portland cement concrete, there was always present a large excess of silica over this free lime, and the result was a kind of acid mixture, instead of the basic mixture that was the consequence of the free lime in cement. This acid concrete resisted better the decomposition of the sulphate of magnesia of sea water, which acted on the basic mortar of concrete—decomposing it and causing free or inert magnesia to be found and sulphate of lime, which had a tendency to crystallize and expand; the consequence of the expansion being disintegration of the concrete.'

The beginning of the fourth paragraph of the right-hand column of page 27 should read as follows:

"As considerable stress has been laid above on the German method of manufacturing cement, and on the Italian use of pozzolana, for sea water concrete \* \* \*

After the 29th line of the right-hand column of page 29, the following paragraphs should be inserted:

"The usual Italian practice for mass concrete laid in harbor work is:

100 to 200 Kilograms of Portland cement,  
1 Part ordinary lime; by volume,  
2 Parts Pozzolana,  
3 Parts gravel or ballast,  
for every cubic meter of concrete.

"In discussing this mixture, Prof. Luigi Luiggi says that such concrete will keep plastic for 6 to 8 hours and allow plenty of time for it to be properly pressed into each and every part of the form without tamping. In other words, the concrete is forced into place by hydrostatic pressure; resulting in a more dense concrete than when a quick setting mixture was used. He states concrete made of the above mixture will not suffer any damage after 12 to 20 hours, even from the wash of the waves and that it gives almost as good results as ordinary concrete laid in the opening for block work, etc.

"A mixture commonly used in Italy for premoulded piles, hollow concrete blocks and floating caissons is:

	Pile work subject to blows	Floating caissons
Portland cement .....	500 to 600 kg.	350 to 400 kg.
Pozzolana .....	150 to 200 kg.	100 to 150 kg.
Sand .....	.40 cu. m.	.40 cu. m.
Gravel or stone—1 in. diameter..	.80 cu. m.	.80 cu. m.
For 1.1 cu. meter of concrete.		

For 1.1 cu. meter of concrete.

"The excess of cement in the pile mixture in comparison with the ordinary mixture quoted above is on account of the heavy blows the piles are subjected to in driving. In the floating caissons mixture the excess of cement is so very small in relation to cost of the reinforcement, forms, labor, etc., as to be negligible; especially in consideration of the great expense necessary to repair an ordinary structure disintegrated under the heavy lateral blows or of sea action. Or as stated above, the increased resistance to sea action more than compensates for the additional amount of cement; especially for that part above low water.

"While a number of experiments made in Scotland show that a 1-2-4 concrete with a 2½ size stone makes the best kind of concrete for mass sea work, at

Southampton it has been found that far better results are obtained in mass concrete deposited under water by using a stone that will pass through a 1-inch ring.

"(NOTE.—The source of the information upon the Scotland experiments seems to refer to premoulded block work not mass concrete deposited under water as per Southampton reference.)

"A method of improving the quality of cement very often practiced in England in connection with the most important concrete structures standing in sea water is that of 'Aerating of the Cement.' The cement is received on the works in bulk form, put into special bins and then turned over a predetermined number of times at regular intervals before being used. It is said that such a treatment of the cement not only increases its resistant power against sea water, but that the increase in bulk more than compensates for the labor cost of the turning."

Seattle, Washington.

HARRISON S. TAFT.

## The Western Metallurgical Field

### Flotation of Lead and Copper Ores

As previously mentioned in this column, many companies over the country are investigating the possibility of treating sulphide ores by oil flotation. Where concentrating mills already are established, the line of investigation has been to test the possibilities of flotation for some of the low-grade mill products, such as middlings or tailings. Some of the lead mining companies in southeast Missouri, in the Flat River district, have recently decided to begin treating slime tailings from the mills by flotation. No statement is given as to the process to be used, except that it will be oil flotation. The mill tailings will have to be thickened from about 50:1 to 4:1 before adding the oil in the flotation machines.

The Consolidated Arizona Smelting Co., of Humboldt, Ariz., also is to adopt flotation for the treatment of a part of its mill product. The present mill contains jigs, tables and vanners. According to Mr. G. M. Colvocoreses, who outlined the proposed plan at a recent meeting of the New York section of the Mining and Metallurgical Society of America, the remodeled plant will continue to make jig and table concentrates. The tailings from these machines will be combined with the fine material from classifiers, and reclassified, the coarse portion being reground to 60-mesh in a Hardinge mill. The resulting fine pulp will be thickened in a Dorr thickener, and treated by flotation. The thickening is considered an important point, as the pulp should go to the flotation plant at a consistency of two or two and a half parts water to one of solids. The exact degree to which grinding will have to be carried is not definitely determined, but practically all the mineral is separated from the gangue at 60-mesh. The problem of dewatering the flotation concentrate is one still confronting the management; further, the roasting of very fine concentrate is likely to introduce greater loss in flue dust.

The recovery by present gravity methods of concentration at Humboldt is given as not more than 65 or 70 per cent. Tests from the flotation plant indicate recoveries ranging from 83 to 96 per cent., but it is not anticipated that a recovery of more than 85 to 90 per cent. will be made on the material treated. The exact kind and amount of oil and acid that will be required are not yet determined, and will be subject to experiment after the plant is in operation. The cost for oil and acid is expected to be from 10 to 20 cents per ton treated.

### Minerals Separation Company's Attitude

At the same meeting of the New York section of the Mining and Metallurgical Society of America, mentioned

above, Mr. J. Parke Channing gave voice to some thoughts on the methods of exploiting flotation adopted by the Minerals Separation Company. Many of the same sentiments have been expressed throughout the West, and the feeling prevails that this company makes the terms for adopting its process needlessly onerous. As Mr. Channing has expressed the idea in forcible manner, we quote the following from his remarks, as published in the Society's *Bulletin* No. 67:

"Unfortunately, the Minerals Separation Company has firmly rooted ideas as to the exact manner in which the process shall be applied, which ideas have met with very little favor among American engineers. What the company would like to do is to take your ore, experiment with it, and if it concludes that the ore can be treated, it will build your mill and treat the ore. Now few engineers feel like leaving the erection of a mill treating 3,000 to 10,000 tons a day to the mercy of English engineers who are used to handling small tonnages. As a result, the company has not been able to induce American mines to cooperate with it.

"A second drawback is that the company desires to treat the whole of a given ore by flotation. The process gives a very high recovery of rich mineral, but in such physical condition that it is not easily amenable to the smelting operations which have to follow. This is the method it proposed to the Caucasus Copper Co., of Russia. There, by the present water concentration, they get a 70 per cent. extraction; by flotation experiments they got 95 per cent. The Minerals Separation Company would agree to permit the copper company to use the process only if applied to the entire ore. The copper company wisely refused to do this, realizing that it would be impossible to treat such fine concentrate in McDougall roasters and reverberatory furnaces.

"The Inspiration mine, I understand, agrees to pay a certain royalty based upon the tons of material actually treated by the process. The construction of the mill is left entirely to the engineers of the Inspiration, and in their case the treatment is to be preceded by water concentration. After a portion of the chalcocite is extracted the remainder is treated by flotation. At Miami we have as yet made no experiments with the flotation process, and I do not know exactly how it will work out on our ore. Any flotation system works better on ores containing pyrite or chalcopyrite than on ores containing chalcocite. At the Inspiration, however, when the middlings were crushed to 100-mesh, they made a very satisfactory saving on the chalcocite."

### Smelting in Nevada

With the operation of copper converters which were recently installed at the smelter of the Mason Valley Company, the plant is now completely equipped for the production of blister copper. Converting operations began about the first of this year, and brought to an end the shipments of matte which have been going to the Garfield smelter in Utah since Mason Valley first began to smelt. The new department has ample capacity to handle the matte now produced from both company and custom ores.

Progress is being made by the new Consolidated Coppermines Co., which consolidated a number of mines in the Ely district, including the Giroux. Churn drills are steadily at work prospecting the ground now under this company's control, and a considerable area of new ground has been found ore-bearing. Financial arrangements were recently completed for the erection of a smelting works. A bond issue has been authorized to the extent of \$3,500,000 at 7 per cent. interest, payable semi-annually. The location of the new smelter is not definitely settled, although a corps of engineers has surveyed a site at Warm Springs which is known to be



avored by the management. In all probability the matter will not be settled until the company knows what attitude the surrounding land owners will take in regard to smelter smoke. The company has asked these people to waive future damage from smelter smoke, and is engaged in now getting their signatures to such an agreement.

#### Purchase of Colorado Gold-Dredging Industry

The Tonopah Mining Co., engaged in mining at Tonopah, Nevada, has recently purchased the property and equipment of the gold-dredging companies operating in the vicinity of Breckenridge, Colorado. The transaction includes the dredges of the Reliance Gold Dredging Co., and the Colorado Dredging Co., the machine shops of the Gold Pan, and several thousand acres of land. The Tonopah company has been looking for a new mining property for some time, and has finally made a new venture by embarking in dredge boats in a search for gold. The sale was one of the largest that has been made in Colorado for years, and is said to have involved a million dollars.

#### Estimated Budget for Bureau of Mines

The estimate expense for conducting the work of the U. S. Bureau of Mines for the fiscal year ending June 30, 1915, has been approved by Secretary Lane of the department of the interior and forwarded to Congress. No action has been taken at the time of writing, but it is probable that the estimate will be allowed. The proposed division of the appropriation is as follows:

General expenses of the bureau.....	\$70,000
Equipment of mine rescue cars and stations.....	30,000
Equipment of Pittsburgh testing plant.....	10,000
Investigating mine accidents.....	347,000
Testing fuels.....	135,000
Mineral mining investigations.....	120,000
Investigations of petroleum and natural gas.....	30,000
Inspection of mines in Alaska.....	7,000
Books and publications.....	2,000
Lands, leases, etc., for mine rescue cars.....	1,000
<b>Total .....</b>	<b>\$752,000</b>

This budget provides for an increase over that of the current fiscal year of \$90,000, represented by the items of \$30,000 for equipment of rescue cars and stations, \$10,000 for equipment for Pittsburgh testing plant, \$30,000 for investigations in petroleum and natural gas, and a \$20,000 increase in the former appropriation for mineral mining. It is understood that part of the appropriation for petroleum and natural gas will revert to mineral mining investigations, on account of the fact that part of the present appropriation for the latter purpose has already been diverted to the former.

As an instance of the need for funds to investigate petroleum and natural gas, the conditions existing in the Cushing field of Oklahoma are cited. The maximum yield of oil in that district has never been over 30,000 barrels per day, and the average value of daily production is probably less than \$20,000. Nevertheless the waste of natural gas from drilling and producing wells in this district has been as high as 300,000,000 cubic feet per day, worth about \$75,000 at domestic rates, or perhaps \$20,000 per day to the producers. It is to study such conditions that the appropriation for oil and gas investigations is asked.

#### Labor Situation in Michigan

The deportation of Mr. Moyer, president of the Western Federation of Miners, from Houghton, and his later indictment by a grand jury, are the principal features of the labor strike in Michigan. Federation officials were indicted for conspiracy to restrain laborers from going to work, for restraining imported laborers from working, and depriving laborers of their rights and property. Thirty-nine officials were named in one indictment.

### The Non-Ferrous Metal Market

During the last week in December the non-ferrous metal market showed more activity than had been in evidence for some time, and sales were large at slightly increased prices. But during the first week of the new year the activity disappeared and the markets experienced a general decline.

**Copper.**—Competitive selling has marked the activity in this market to such an extent that consumers have been inclined to hold off on account of the demoralization in prices. Prices for electrolytic have declined daily and the market for Lake is wholly nominal. The latest available quotations are 13.80 to 13.90 cents for electrolytic, with the market weak.

**Tin.**—Considerable business was transacted in the domestic market during the last of December, but with the decline in the London market in the first week of January domestic buying ceased and a low price was established. January tin was quoted at 36¾ cents.

**Lead.**—The leading producer has fixed prices, which showed a slight advance during the holidays, but again declined in January. Independent producers were at first inclined to let the A. S. & R. Co. take the business, but later offered metal liberally. The last quotations are 4.10 cents New York, and about 4 cents St. Louis.

**Spelter.**—This market has been dull with little fluctuation in prices. Sales are not heavy and consumers are buying only for immediate needs. New York quotations are 5.20 to 5.25 cents, with St. Louis at 5.05 to 5.10 cents.

**Other Metals.**—The aluminium market shows a slight improvement, with quotations at 18½ to 19 cents. Antimony is quiet, with fair sales for immediate delivery. Various brands are quoted at from 6 to 7.30 cents. A steady business prevails in quicksilver, with New York prices \$38 to \$39 per flask of 75 lb., and \$38.50 at San Francisco.

### The Iron and Steel Market

The slight improvement in the general tone of the iron and steel market, referred to in last report as occurring in the closing days of December, has developed into a definite and clearly market improvement in the past month. There has as yet been nothing like the spectacular revival which has often characterized the industry's recovery from depression, but there has been a decided improvement in bookings and production, and a slight stiffening in prices, amounting in the case of a few products to definite advances.

Many of the steel mills closed entirely over the holidays, and some of the attendant blast furnaces, to the number of more than a score, were banked. Resumptions occurred at various times in the first fortnight of January and at the close of the month the steel industry is operating at fully 60 per cent of its maximum capacity, while the actual production in the month was between 50 and 55 per cent of capacity. These percentages compare with operation at the rate of about 50 per cent in the fore part of December, and production for the month as a whole little if any over 40 per cent of capacity.

There has been very little long term contract tonnage booked, the mills instead looking for definite orders, with specifications attached. It is possible that the refusal of mills to protect buyers by giving them the usual option or "jug handled" contracts has been largely responsible for the increase in actual specifications, particularly since the lowest prices have been named on definite orders rather than on contracts. At



the lowest—the general level being now discernibly above the minimum—prices did not reach the low average of two years ago by about \$2 a ton, and this fact is variously explained. The mills have certainly been under as much competitive strain lately as at the former minimum, perhaps under more. Increased cost of production, through the general wage advance of February 1, 1913, is cited as one cause, while another seems to be that the mills have a different philosophy now.

With the low tariff in effect there is less promise than formerly of relatively high prices for any period in the future, and there is therefore less inducement to start a buying movement by naming very low prices and then expecting a prolonged advance in prices to produce a fair average. In many cases it is known that the sales offices are working more closely in harmony with the operating departments and paying more attention to the cost sheets.

### Pig Iron

Buying of pig iron in January was fairly heavy, and was marked by the first definite buying for forward delivery since last midsummer. For months buyers had covered only for immediate requirements, but late in December some of the larger buyers began to adopt the idea that if prices were not definitely advancing, they at least stood much more chance of averaging higher than of averaging lower, during the first six or nine months of the year. Buyers who have covered, however, have not taken tonnages equal to their full normal requirements. Under stress of competition produced by important inquiries prices declined in many markets early in January, but at the close of the month the advancing tendency seems to predominate, and at Buffalo there has been a clear cut advance of 50 cents a ton.

The manufacturers of Bessemer and basic pig iron in the valleys are as a rule holding their output at higher prices than are openly quoted as a market. Quotations stand as follows: No. 2 foundry, f.o.b. Birmingham, \$10.50 to \$10.75; No. 2X foundry, delivered Philadelphia, \$14.75 to \$15; No. 2 foundry, f.o.b. furnace, Buffalo, \$12.50 to \$13; No. 2 foundry, delivered Cleveland, \$13.25; No. 2 foundry, f.o.b. Chicago furnace, \$13.50 to \$14; at valley furnaces (90 cents higher delivered Pittsburgh), Bessemer, \$14; basic, \$12.50; No. 2 foundry, \$13; malleable, \$12.75; gray forge, \$12.50. Late in December the Carnegie Steel Company appeared as a seller of ferromanganese, which it had previously made only for its own use, and it closed several contracts with consumers for their requirements during the first six months of the year, on the basis of a price to be named each month, the price to be about \$2 below the price of imported material. The price for January was fixed at \$47, delivered to points near Pittsburgh. In a short time the English and German makers reduced their price from \$47 to \$45, f.o.b. Baltimore.

### Steel

Late in December a slight further weakening occurred in unfinished steel, chiefly with respect to open-hearth sheet bars, which were offered down to \$20, maker's mill, Pittsburgh or Youngstown, the quotation on Bessemer bars remaining at \$21, while billets were not generally quoted below \$20. After the 15th of the month the Carnegie Steel Company announced its withdrawal from the market as a seller of billets or sheet bars and the tone of the market began to improve, until it became difficult to buy open-hearth bars at the old price.

No clear cut advance, however, has occurred in unfinished steel, except that rods have been advanced from \$25 to \$26.

### Finished Steel

The trend in unfinished steel prices has been in the upward direction, though there have been few definite advances. Bars, plates and shapes late in December could be done at 1.15 cents, on attractive tonnages for quick shipment, though the open quotation was 1.20 cents, and the concession is now practically withdrawn, except as to bars and plates in Chicago territory. During the last week in the old year and the first week in the new mills booked definite orders for wire nails at \$1.50, and then firmed up to a \$1.55 basis. Sheets were done freely on the basis of 1.80 cents, but early in January firmed up to 1.85 cents, and on January 22 the leading interest made the somewhat radical advance to a basis of 2 cents, a price which the independents will probably reach early in March.

In all cases the firming up in prices has been due to the receipt of heavier bookings in the form of actual specifications.

Prices named below are f.o.b. Pittsburgh, unless otherwise stated:

Rails, standard section, 1.25c. for Bessemer; 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.20c.

Shapes, 1.20c.

Steel bars, 1.20c., base.

Iron bars, 1.35c., Pittsburgh; 1.22½c., Philadelphia; 1.10c., Chicago.

Wire nails, \$1.55 per keg, base; plain wire, 1.35c., base.

Sheets, blue annealed, 10 gage, 1.45c.; black, 28 gage, 1.90c. to 2c.; galvanized, 28 gage, 2.90c. to 3c.; tin mill black, 1.85c. to 1.95c.; painted corrugated, 28 gage, 2.10c. to 2.20c.; galvanized corrugated, 28 gage, 2.95c. to 3.05c.

Merchant steel pipe, ¾ to 3-in., 80 per cent. off list.

Steel boiler tubes, 3½ to 4½-in., 71 per cent. off list. (Revised from 69 per cent. on January 2d.)

Standard railroad spikes, Pittsburgh, 1.50c.; Chicago, 1.50c.

Structural rivets, 1.70c.; boiler rivets, 1.80c.

Cold rolled shafting, 64 per cent. off list.

## A Symposium of Papers on "Undeveloped Elements"

The next meeting of the New York section of the American Electrochemical Society will be held in the Chemists Club Building in the evening of Friday, February 6.

This meeting will be a joint meeting with the New York sections of the American Chemical Society and the Society of Chemical Industry.

The subject of the evening will be "Undeveloped Elements" and the program is as follows:

"Opening up the Field of Unused Elements." By Dr. Charles Baskerville.

"The Present Status of Cobalt." By Dr. H. T. Kalmus.

"The Present Status of Boron." By Dr. E. Weintraub.

"The Present Status of Tungsten." By Dr. R. W. Moore.

By "undeveloped elements" is meant those elements which are available as by-products or otherwise in excess of present demand. Some are dead, such as tellurium; some are comatose, such as selenium and cadmium; some are very limited in their applications, such as bromine.

Discussion will not be limited to the actual papers presented.

It is hoped that an interesting exhibit can be made of products relating to the subject.

## Patent Suit Decision on Manufacture of Chill-Proof Beer

A decision has just been rendered in the patent suit for the manufacture of chill-proof beer in the United States District Court of the Eastern District of New York. The plaintiffs were Max Wallerstein and Leo Wallerstein, suing the S. Liebmann's Sons Brewing Company for infringement of Leo Wallerstein's patents, 995,820 and 995,824.

The decision of the court, written by Judge Van Vechten Veeder, is in favor of the complainants, the patents in issue being held valid and infringed.

The following quotations from the decision seem to be of general interest to chemists:

"The development of the bottling industry brought about a change in the method of consumption of beer. Instead of being served from the keg, or at all events within a short time after leaving the brewery, it was shipped long distances and kept for considerable periods of time. When thus kept, even at ordinary temperatures, beer tends, from a lack of stability, to become hazy and cloudy, and to deposit a sediment. But in this country it is customary to drink bottled beer very cold. This chilling causes brilliant beers or sparkling ales to lose their brilliancy and to become hazy and cloudy. It was soon found that under conditions of long shipment and storage the most carefully brewed beer developed micro-organic growths. To eliminate this brewers adopted the practice of pasteurization; that is, the beer in bottles was subjected to a temperature of from 140 deg. to 150 deg. F. for about half an hour. But while pasteurization prevented the growth of micro-organisms, pasteurized beer was found to be particularly sensitive to cold and unstable. There remain in the beer after steaming certain substances of an albuminous nature, which, while invisible at the time of steaming because dissolved, are slowly affected by a number of causes and become less readily soluble, especially at low temperatures, finally causing haziness or sedimentation and thus rendering the beer unsightly and unrepresentable.

"The production of stable and chill-proof beer was therefore a problem of vital importance to brewers. The evidence leaves no doubt of the reality of the problem or of the difficulty involved in its solution."

"The patents in suit produce chill-proof and stable beer by adding to the beer at the proper stage a minute quantity of a proteolytic enzyme active in an acid medium. Proteolytic enzymes are divided into classes according to the medium in which they act, that is, whether acid, neutral or alkaline. The patents in suit refer to four proteolytic enzymes active in acid medium: pepsin, an animal enzyme obtained from the stomach of pigs; papain, an enzyme derived from the pawpaw; bromelin, a vegetable enzyme derived from the pineapple, and malt peptase, derived from malt. Enzymes suitable for the purpose described are widely distributed in the vegetable and animal kingdoms, and are readily prepared in concentrated form by known methods.

"The procedure by which proteolytic enzymes active in an acid medium are employed for the purpose of chill-proofing and stabilizing beer, is exceedingly simple, and is specifically set forth in the patents in suit: 'According to the present process, there is added to the beer at any suitable stage of the brewing, that is to say at any period subsequent to the cooling of the wort, and usually after the conclusion of the main fermentation, a proportion of proteolytic enzymes active in slightly acid media sufficient to modify the proteids contained in the beer in such manner that they will not be precipitated upon chilling subsequent to pasteurization, the beer being rendered chill-proof in the sense that it is

capable of remaining brilliant even when kept upon ice for a considerable time. In practice it has been found advantageous in most cases to add the enzymes to the clarified beer shortly before bottling. During the pasteurization which follows the bottling, the enzymes become active, and those proteids which would cloud the beer when chilled are so modified by the proteolysis that the resulting beer will remain clear and brilliant, being no longer sensitive to cold.'"

"Since the evidence satisfies me beyond any reasonable doubt that the defendant's beer is made chill-proof and stable by the use of proteolytic enzymes active in acid medium, and that the infringement is a deliberate and flagrant appropriation of Wallerstein's disclosures, attention may be directed at once to the grounds upon which the validity of the patent is attacked.

"The defendant introduced much testimony to show that certain extracts have long been made by compounding pepsin with malt liquor, the latter serving as a carrier for the former. It may be said at the outset that the defendant's testimony with respect to these malt preparations is wholly unsatisfactory. The testimony of the defendant's witness Wyatt was so obviously unbelievable that its counsel stated upon the argument that it would not be relied upon."

"My conclusion is that the patents in issue are valid and infringed. The complainants may have the usual degree."

## Bitumen and Electric Main Explosions

The British Board of Trade has appointed a committee to investigate the explosions connected with electric mains laid in bitumen. The inquiry is the outcome of an explosion of gas at Hebburn-on-Tyne, several months ago, by which two houses were blown up and two persons were killed, and which was attributed to gas generated from the bitumen in the trough at a bend where a fault in a direct-current vulcanized-bitumen-insulated cable at a moist spot caused a short circuit and consequent destruction of about 6 ft. of cable and the bitumen in which it was laid.

The fault was very close to the house, the gas found its way through loosely constructed foundations into large air spaces under the ground floors, air was supplied by a ventilator inlet facing the fault, and, in some unascertained way the mixture became ignited, with the result stated.

Hitherto considerable divergence of opinion has existed as to the causes of joint-box and similar explosions, and on some occasions very elaborate theories have been advanced. In the case of an explosion in London several years ago certain experts attributed the ignition of the explosive gaseous mixture to the action of water on metallic sodium produced by the electrolysis of sodium salts derived from the surrounding soil; but in this instance the cable was not laid in bitumen and the hydro-carbon gases were said to have been derived from a neighboring gaspipe.

Bitumen is so extensively used both as filling for cable troughs and, when vulcanized, as a dielectric covering for cables that all who are concerned will regard an official inquiry with satisfaction.

## Bureau of Standards Analyzed Brass Samples

The Bureau of Standards, Washington, D. C., is prepared to issue a sheet brass of the following composition, approximately: Sn, 1; Pb, 1; Cu, 70.3; Zn, 27; Fe, 0.3; Ni, 0.5. The fee, payable in advance, is \$3 per sample of about 150 grams weight.



## Test of a Vacuum Pan

BY E. W. KERR

The following data were obtained from a test of a vacuum pan in a Louisiana sugar house where white sugar is made direct from the cane. The pan tested was of the calandria type, known as the Stade express vacuum pan.

This type is shown diagrammatically in Figs. 39 and 40 on pages 349 and 350 of the July, 1911, number of METALLURGICAL AND CHEMICAL ENGINEERING. It should be stated, however, that the condenser of the pan tested was a dry condenser and differed materially from the illustration mentioned.

The object of the test was to secure data relative to heat transmission, also steam consumption. The test was, in fact, a history of one strike.

The syrup fed during the test was measured in large storage tanks which were carefully calibrated.

The density of the syrup fed and of the masse-cuite leaving was obtained by means of Brix spindles which had been carefully calibrated.

The weight of condensed steam leaving the pan was measured by means of a Venturi meter, the manometer of which was read every two minutes throughout the test.

The condensed steam was removed from the pan and pumped directly into the boilers by means of an automatic receiver pump.

The receiver being of liberal capacity, the flow of condensed steam from the pan was fairly steady and for this reason the meter readings should be fairly accurate.

The amount of water removed from the syrup in the form of vapor during the boiling process was calculated from the weight of syrup fed and the initial and final density.

One of the items difficult to obtain in determining a heat balance is that of the specific heat of the syrup, also that of the masse-cuite.

In arriving at this quantity it was assumed that the specific heat of the mixture of sugar and water was equal to the sum of the heat in the dry matter plus the heat of the water, degrees Brix, representing the per cent of solid matter.

It will be noticed that the purity of the product was 71.5 per cent, that is, of the total dry matter 71.5 per cent was sugar.

In the specific heat determination it was assumed that all of the solid matter was sugar, which may not be absolutely accurate, though it is probably very nearly so.

The specific heat of sugar was taken to be 0.301.

I hope the results of this test will be found interesting. So far as I know no data of this nature have been published.

The results of the test are given concisely in the table in the right-hand column of this page, together with a heat balance sheet, showing the amounts of heat entering and leaving and the heat lost in radiation and not accounted for.

Louisiana State University and Audubon Sugar School.  
Baton Rouge, La.

## Summary of Test

1. Type of pan ..... Calandria (Express)
2. Type of condenser ..... Counter current jet (Barometric)

### DIMENSIONS

3. Heating surface, square feet ..... 750
4. Diameter of pan, feet ..... 13

### PRESSURES

5. Pressure of steam to pan calandria, lbs. gage ..... 28.8
6. Vacuum in vapor space, inches of mercury ..... 23.4

### TEMPERATURES AND DENSITIES

7. Temperature\* of steam in calandria of pan ..... 272
8. Temperature of steam, condensed ..... 270
9. Temperature in vapor space ..... 143
10. Temperature of entering syrup ..... 175
11. Temperature of masse-cuite leaving ..... 156.7
12. Temperature of injection water entering condenser ..... 64
13. Temperature of injection water leaving condenser ..... 132
14. Density of syrup entering, Brix ..... 49.4
15. Density of masse-cuite leaving, Brix ..... 94.8
16. Purity of syrup fed ..... 71.5

### TOTAL QUANTITIES

17. Duration of test (strike), hours ..... 6.95
18. Volume of syrup fed, gallons ..... 15,387
19. Weight of syrup fed, pounds ..... 152,932
20. Per cent evaporation ..... 47.89
21. Weight of water evaporated from syrup, pounds ..... 73,139
22. Weight of steam condensed, pounds ..... 93,815
23. Weight of cooling water to condenser, pounds ..... 1,100,010

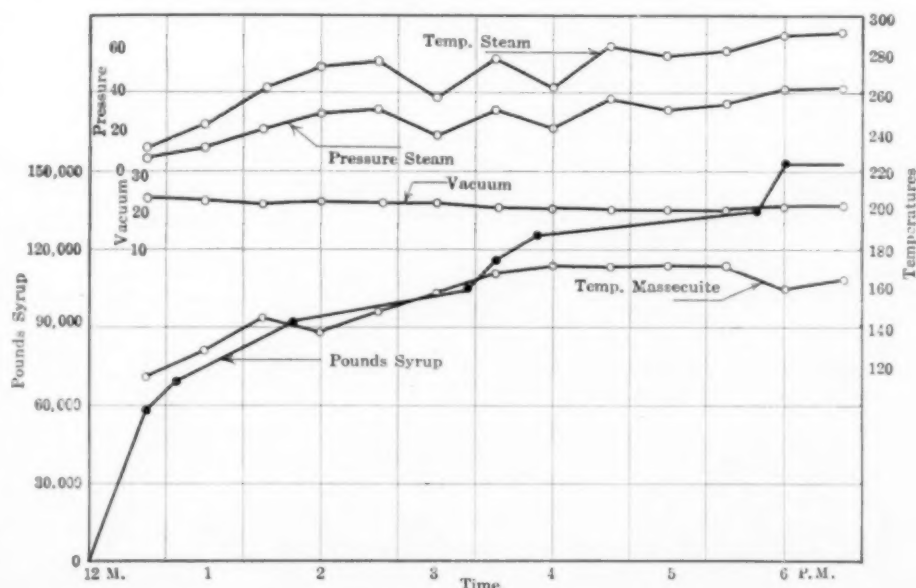
### HOURLY QUANTITIES

24. Syrup fed, per hour, pounds ..... 25,278
25. Water evaporated from syrup per hour, pounds ..... 12,089
26. Steam supplied per hour, pounds ..... 12,200

### GENERAL QUANTITIES

27. Total water evaporated from syrup, per pound of steam supplied ..... .778
28. Total water evaporated per square foot heating surface, per hour ..... 16.12
29. Temperature fall, actual ..... 115.8
30. Coefficient of heat transmission ..... 166.3
31. Cooling water per pound of vapor ..... 15.04

\*All temperatures are in degrees Fahrenheit.



GRAPHICAL LOG, TESTS OF A 13-FT. EXPRESS VACUUM PAN

## Heat Balance

### ENTERING

Heat entering in steam, B.t.u.'s.....	109,849,154
Heat entering in syrup, B.t.u.'s.....	15,089,800
Entering, total .....	124,938,954

### LEAVING

Heat leaving in masse-cuite, B.t.u.'s.....	4,514,209
Heat leaving in vapor, B.t.u.'s.....	82,127,783
Heat leaving in condenser steam, B.t.u.'s.....	22,328,298
Heat leaving, total .....	108,970,290
Heat lost in radiation and not accounted for.....	15,968,754



## Electric Iron Smelting at Hardanger in Norway

BY JOH. HÅRDEN

Mr. G. Oedquist has in an interesting and suggestive paper,\* read before the Polytechnic Society of Kristiania, Norway, given a comparatively full report of the facts which, according to his mind, have caused electric smelting to give an unfavorable result at Hardanger, in Norway, as far as the economy goes.

As the paper is evidently written with the view to lay clear such instances as are likely to occur in other places, a résumé of the contents seems justified; a few remarks of the present author's experience on similar lines will be added. The main points of Mr. Oedquist's paper are:

Since the problem of electric smelting of iron ore has the greatest future and importance for such countries as Scandinavia, on account of the tremendous sources of both water power and deposits of high-quality iron ore (which factors are essential for the success of electric smelting), it is well worth while to go into the causes of the unsatisfactory outcome of the trials, so far made at Hardanger. A few comparisons will be made between this plant, where coke was used exclusively, and a few others, where charcoal is used.

The author of the paper in question does not mention the facts that the choice of reducing agent—coke versus charcoal—is an important factor in the whole problem, yet all available data seems to point out that this must be so, at least for the present, and it appears to the present author that the coal question is of at least as much importance as the question of cheap power and good ore.

As far as can be concluded from the various reports, the operation with coke direct in the furnace has essential drawbacks, some of which appear in the report, as will be seen. In the first place, the conductivity of the coke is high, hence a large current density at a lower voltage is likely to be required, and this will in turn increase the electrical losses and cause the plant to be more expensive, with a lower efficiency. This is borne out by the paper, as will be seen. Further coke is always richer in sulphur and, therefore, demands a larger addition of lime, which increases the dead ballast in the furnace, thus lowering the output; this is also mentioned, though in a somewhat different way. True, coke may be obtained with a low percentage of sulphur, but such coke is much more expensive and throws the balance the wrong way.

Against this, charcoal is much more suitable, on account of its lower conductivity, low content of sulphur, and its gas producing properties. But charcoal is expensive, even at its best, and there is likely to be difficulty to obtain a proper supply of charcoal in Norway, especially at places like Hardanger, where the other factors may be more favorable; hence if charcoal were to be used, it must be subjected to import or long freight, but this burden it cannot very well bear on account of its initial price and its bulky mass.

Even in Sweden, where charcoal may be obtained more readily, the question has become "a burning problem." It is reported elsewhere that owing to the large demand for charcoal wood, the manufacturers are gradually forced to make use of younger, quick-growing trees, on which the percentage of bark is rather high. As the bark contains a larger proportion of phosphorus, this obnoxious element is introduced into the otherwise pure ore and tends to lower the quality of the product. One should think that the phosphorus should

be eliminated in the charring process, but report says that this is not so, and to remove the bark would mean an increased cost and loss of material.

This, of course, does not apply so much to charcoal made from refuse from saw mills, since the wood is generally barked before putting it through the saw mill; but it is generally assumed that the coal from "natural" wood has a higher value, if made from the right kind of wood.

From this it would seem that the coal question for electric iron smelting is a very important one.

But to recur to the paper under review, it is stated that the conclusions in the report are made from official statements, made by the Electrometallurgical Committee regarding the trials at Hardanger, and may be found in *Teknisk Ugeblad*, 1913, page 192.

Mr. Oedquist concludes that reading through these statements one cannot help arriving at the surmise that everything was relatively well and good, and that the poor results were to be found here to "misadventure" and outside conditions, particularly to the use of unfavorable ores in some cases, bad roasting of the ore, some of the electrical details not being suitable, unfavorable conjunctures and high freights.

Regarding the furnace type, however, and its adaptability for coke, the committee maintains that this has no part in the failure.

Mr. Oedquist in his paper does not agree with the committee on that point, but thinks that on the contrary the type of furnace design and its unsuitability for working with coke has had a great effect upon the results and in a high degree caused the expectations made at the Hardanger works to be a disillusion.

He endeavors to give strength to this claim in his paper and to explain in what way he has arrived at this conclusion.

As regards the unfavorable conjunctures referred to, the author of the paper says, he does not intend to go into this question at large, nor the freight conditions, as it is outside the scope of his issue; he will only mention that these conditions are always subject to changes and must be taken into consideration *a priori*. Especially as the Hardanger works has only taken a part of the whole program laid out in the prospectus. However important these factors may have been, one must look deeper into the matter in order to find the actual reasons for the unsatisfactory results obtained.

Proceeding to do so, the author commences with some scathing remarks regarding the electrical equipment at Hardanger.

The committee says in regard to this that the choice of transformers and regulating arrangements very soon proved to be unsuitable for the purpose. Furthermore, the manner in which the leads were laid out from the secondary to the furnaces, and the way the connections to the electrodes were carried out, caused the system to work under such bad conditions, that only about two-thirds of the power contracted for was available at the furnace. The committee adds:

"As the plant was carefully inspected electrically before taken into use, without any mentioning of these faults, one was led to believe for a long period that the bad results were due to faulty operation of the furnace itself. Only later, as the conditions were tested in a proper way, it was found that a power factor of only 0.60 was obtained."

Consequently, under the whole of this period, the first furnace was working with a power factor of 0.60, and it was only in January, 1913, shortly before the second furnace was to be started, that the leads were laid differently and the carbon arrangements altered so as to give a better effect.

The arrangement of the transformers and the regu-

\*A second part of the paper was also read, but has not yet been published. The first part, which is discussed in this article, has been published in *Teknisk Tidsskrift*, December, 1913.

lating system remained unaltered, however, as their change would have caused too much expense.

The voltages on the secondary side could be regulated between 50 and 78 volts.

These appear to the present author to be too high average values. Compared with other three-phase furnaces, operating under conditions which would call for a higher voltage than required in a closed iron reduction furnace, it is found that the highest voltage required when starting up and while the furnace is still cool is 62 volts, while the normal working voltage after the first two or three hours, with a normal slag, is just under 50 volts, or even down to 45 volts. Hence it seems very likely that a regulation of from 30 to 65 volts would have been much more advisable, perhaps with a small auxiliary voltage raiser for a few per cent of the total power only, to be resorted to in cases of emergency, to break through the resistance of a stubborn charge.

It is true that such a lower range of voltage on the secondary would have rendered the construction of the transformers more difficult and would have increased the cost of the plant at first, and it is quite likely that this consideration may have tempted to instal the higher rating; but on the other hand, with a plant as the one in question, it seems a dangerous policy to save at the start and to risk the life of the enterprise in the end.

According to the paper, the Electrometallurgical Committee which visited the plant in April, 1913, when some of these faults had been corrected, carried out some measurements on the second furnace. The power factor was then up to 0.91 and the electrical efficiency 0.885 per cent at a pressure of 78 volts.

At 50 volts, however, it was found that the normal load on the furnace was unattainable and both the power factor and the efficiency were low (though the actual figure was not stated).

The consequences of the above statements are that as far as the first furnace is concerned 33 per cent, at least, of the total power contracted for was not available in the furnace, on account of unsatisfactory arrangements.

The present author thinks that the above conclusion is not strictly proven to that extent, as the lowest working figure is not given; and although the power factor was rather low, it would mean wattless current which is, of course, not paid for, unless a lump sum is paid for a certain quantity of power, held available at the supply works, but this is not stated.

The second furnace was started in March, 1913, and showed the advantage of a better power factor and higher efficiency, at least as far as the higher voltages are concerned.

That the output of this furnace, however, in spite of this, was not higher than 1.87 ton pig iron per calculated horse power year during March depends on other causes, which the reporter proceeds to explain later on.

In order to show the results at Hardanger more clearly, some curves are issued, made by the electrical committee and based on the calculated figure of a 70 per cent useful efficiency of the furnace per hp year, arranged for various per cent of pig iron calculated on the charges of ore, limestone, etc. One of these curves is shown in Fig. 1.

The upper curve refers to furnaces in which one has 33 per cent of  $\text{CO}_2$  in the furnace gases; the lower curve refers to such where the gases are chiefly CO.

Certainly other factors than the percentage of iron alone govern the output, namely the degree of oxidation of the ore and its assay in general, the analysis of the pig iron and the slag, etc., but as the percentage of iron

is the most important, the other factors have been so far left out of consideration, and the diagram as shown has been adhered to, in order to simplify the understanding of the conditions.

For comparison a few points from other plants are drawn in, namely from the results at Trollhättan ( $T_1$  and  $T_2$ ), from Strömsnäs trials (also at Trollhättan) marked (S), from Uddeholm ( $U_1$  and  $U_2$ ) and the results from Hardanger (H) during the period March 2 to March 28.

During the last mentioned period at Hardanger, no gas circulation was used in the furnace, wherefore these results actually belong to the lower curve, and from this will be seen that the furnace was only utilizing about 70 per cent of the power supplied; a higher figure is very unlikely to be obtained with this furnace under the prevailing conditions.

It is to be remembered regarding these figures that they refer to the furnace in full operation during the whole period, so that the 70 per cent do not include any stoppages or heating up, repairs, etc. Also it is calculated on the total energy actually supplied to the furnaces, not on the amount which must stand available at the transformers for emergency, etc.

The author of the paper calls this figure of efficiency "apparent" efficiency, which should not be regarded as the efficiency of the plant and should not be laid as

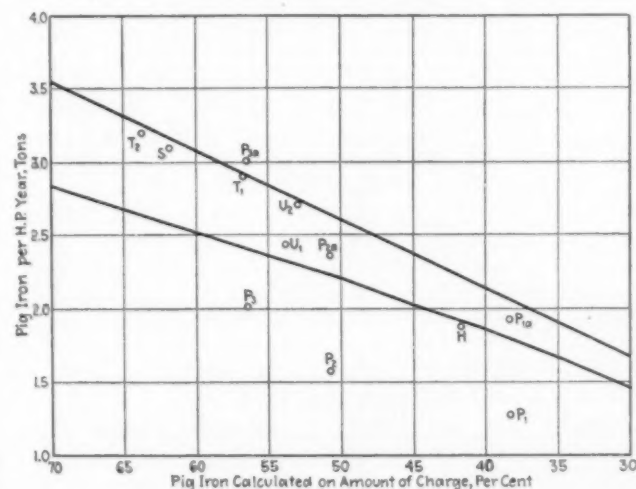


FIG. 1—RELATION BETWEEN POWER CONSUMPTION AND PERCENTAGE OF PIG IRON IN CHARGE

basis for estimating the whole results of the works. This is only natural, as the figure obtained for any one single furnace during a short period cannot be regarded as a measure of the conditions of the complete plant, since the furnaces and periods of smelting differ; besides power may also be used elsewhere than on the furnace terminals.

All values given in the diagram No. 1 are figures based on this principle.

The work carried on at Hardanger may be divided up into three campaigns or smelting periods, whereby period III is a part of period II, and the yield during these periods are shown in Table I.

TABLE I.

No.	During the period	Per cent. of iron against the charge	Tons of pig iron calculated per H.P. year
Period I.—			
From Nov. 7, 1911, to April 13, 1912.....	38.1		1.28
Period II.—			
From July 10, 1912, to Feb. 20, 1913.....	50.7		1.58
Period III.—			
From Aug. 25, 1912, to Sept. 8, 1912.....	56.4		2.01

The figure for the power in this table is taken from the primary side of the transformers and, therefore,



include the losses in these as well as in the copper connections and electrical equipment of the furnace.

These results are found in Fig. 1 under the marks  $P_1$ ,  $P_2$  and  $P_3$ .

In consequence of the faults in the electrical arrangements already stated, the actual quantity of power used in the furnace proper only was about two-thirds of the recorded power, and if this is taken into consideration, the figure for the yield may be altered so as to read (about) 1.92, 2.37 and 3.015 tons, respectively, per calculated horsepower year for the three periods, respectively.

The corresponding values are shown in Fig. 1 under  $P_1a$ ,  $P_2a$  and  $P_3a$ .

As will be seen from Fig. 1, the results of the periods I and II stands between the two actual curves, and as the gas circulation is recorded as being rather low, one may be justified in assuming that the "apparent" efficiency in both cases was approximately 70 per cent.

The point " $P_3a$ " stands somewhat over the upper curve, but as this gives the "apparent" efficiency of 70 per cent at a gas proportion of 33 per cent  $CO_2$  and as the proportion of  $CO_2$  is given in average to be 39 per cent one may also here assume an average efficiency of 70 per cent.

Consequently both furnaces seem to have given an "apparent" efficiency of 70 per cent after the losses due to faulty arrangement of connections, etc., have been deducted. It may be mentioned that the measuring instruments in the plant show a slight error, but this is of minor importance on the whole.

It is noteworthy that these results follow the calculated curve fairly well, wherefore it is safe to say that the efficiency of this type of furnace will in the average give 70 per cent apparent efficiency generally.

The diagram Fig. 1 shows clearly how the faulty electrical arrangements influenced the output on the first Hardanger furnace; and not only this, but these arrangements were of great importance upon the other working conditions, at any rate indirectly.

As one of the indirect consequences may be mentioned the large

#### Percentage of Scrap

produced. The Electrometallurgical Committee has drawn attention to the difficulties connected with the tapping of the furnace and proper maintenance of the taphole, and that it was often necessary to disconnect one of the phases in order to obtain sufficiently high voltage to melt out the taphole.

This proves that it was difficult to obtain a sufficiently high temperature in the furnace, and this is quite likely, since a furnace which is designed to receive a certain quantity of heat electrically and which is only receiving about two-thirds of the power, will of necessity run rather cool.

The consequences were also inevitable, and it seems quite permissible to lay the chief fault of the high percentage of scrap produced to this cause.

Table II shows the amount of scrap produced:

TABLE II.		
	Percentage of scrap counted on total output	Smelting stoppages in per cent
First Furnace—		
Period I .....	about 25%	20.8%
Period II .....	" 20%	8.5%
Second Furnace—		
Period IV, March 3 to March 28, 1913 ..	" 10%	14.0%
Period V, April 26, 1913, to June 28, 1913 ..	" 5%	not stated

The percentage of scrap from the second furnace is visibly smaller than that from the first, and this must be due to the more efficient way in which the conductors are laid and to the better electrical arrangement generally, whereby it was possible to increase the

power in the furnace, as compared with the first furnace.

The interruptions in the smelting play, of course, also a considerable part in this respect, but lack of sufficient heat is more important, as is evident from a comparison between period IV and II.

Truly the stoppages are only taken in hours proportionate to the total period, without stating the numbers of stoppages, but we must assume that the figures given represent the approximate influence of the interruptions. What influence this large percentage of scrap has upon the whole economy of the plant is unnecessary to point out. It speaks for itself.

#### The Gas-Circulation

The above-mentioned difficulties in obtaining a sufficient heat in the furnace may probably also have accounted for the fact that the gas circulation was discarded subsequently at Hardanger. It was found necessary to increase the heat in the furnace at all cost and as one of the means to do so was the abandoning of the circulating of the gas, this was given up by and by.

The circulation of the gas causes, as is well known, a lowering of the temperature in the furnace cavity, because a certain quantity of heat energy is used up by the reaction of the  $CO_2$  with the heated carbon, forming  $CO$ , which is a heat-binding process; further, heat is expended by raising the mass of gas up to or near the temperature of the smelting zone, which heat is then carried up in the shaft.

Of course, a part of this heat is recovered through the preheating of the charge, but as the gases strike rather rapidly through the shaft, a good deal of heat is carried further away, outside the furnace. Hence the gas circulation will lower the temperature in the smelting zone and raise it in the shaft, with the consequence that if gas circulation is employed the gases leaving the furnace will contain more of  $CO$ , than otherwise, which again influences the coal consumption and the power consumption in such way that both of these factors will be lower if gas circulation is used.

The author does not prove this statement by figures. It is clear from his reasoning that the coal consumption should be lower, but it is not equally clear that the total power consumption for the whole furnace should be lower, although the process is less heat requiring as far as the actual reduction of the ore goes, if the final gas product is higher in  $CO_2$ . Against this stands the heat expended in dissociating the  $CO_2$ , raising of the temperature of the gas mass and alteration of the direction of the heat gradient.

This question could without doubt be answered by means of the results obtained at the trials of the Swedish Iron Institute at their plant at Trollhättan, but the author of the paper has not made a comparison.

As the gas circulation was abandoned, in order to obtain a higher temperature, the coal consumption increased from 336 kg coke per ton of pig iron with the gas circulation, to about 385 kg without same.

The power consumption increased as well, which can be seen from the diagram, Fig. 1, where the lower curve gives a fair indication of the amount of power without the gas, and the upper curve with the gas.

But as the temperature of the furnace was of a much higher importance one had to give up the advantages of the gas circulation and it appears that the management arrived at the conclusion that it would be generally better under the prevailing circumstances to carry out the process without the gas circulation all together, because after alternative runs with and without circulation for a time, it was not used again during the period after December 14, 1912.



But, as will be seen from the above, the circulation of the gas has a greater importance as soon as the conditions are adequately arranged to obtain a good heat electrically in the furnace cavity.

If, therefore, the abandoning of the circulation was justified for the first furnace, in order to raise the temperature the case is different with the second furnace. Since the electrical arrangements had been altered here, it ought to have been possible to obtain the proper heat even with gas circulation, and so obtain the advantages of gas circulation.

As the diagram Fig. 1 shows, when gas circulation is used, so that the furnace gases contain about 33 per cent  $\text{CO}_2$ , the output per calculated horsepower year can be raised by 15 to 25 per cent.

Of course the circulation may cause other difficulties, but as regards the so-called "slig," i. e., the wet or dry, powdered ore concentrate from which briquets are pressed, the experience at Hardanger seems to indicate that their employment offers no particular difficulty which would prevent the use of gas circulation, as it was stated that the average gas pressure was about 300 millimeters water gauge.

Should, however, the conditions be so that all the furnace gases may be utilized for power, etc., one may be able to recover a part of the heat energy expended this way.

#### The Ore Used

It has been pointed out from many sides how important it is to use a high-grade ore for the electric smelting and that the content of iron in the charge will greatly influence the electrical efficiency; this is also very fully demonstrated in the diagram Fig. 1.

It is in most cases more advantageous to concentrate a poorer ore for use in the electric furnace, so as to eliminate the bulk of the dead gangue previously; this is as a rule quite clear, since the gangue forms a heavy ballast, which increases the slag and the total losses and taxes the furnace unnecessarily.

If coke is to be used as a reducing agent, it is necessary to work with a very basic slag in order to obtain a pure material. The addition of lime is, therefore, larger, and will cause a decrease of the percentage of iron in the charge, wherefore in that case it is still more important to use high-grade ores; it is also rather important to use an ore with a lower percentage of quartz, so as to avoid a larger addition of lime.

It seems most advisable to use a mixed ore of basic and acid nature, so that the quantity of lime may be minimal on account of the ore. Of course, one must see to it that the quantity of slag will not be too low; this, however, is less dangerous with electric smelting, as the slag is of less importance here than with ordinary blast smelting.

A number of other features of the ore used are more or less essential for good working of the electric furnace; but as the author says, it would carry us too far to discuss these here. Each kind of ore should be carefully investigated in this respect previous to the smelting.

The author is no doubt quite correct in this respect; but as the practical experience has shown, it is very difficult in the daily routine of work to carry out proper investigation in each case, especially if a greater variety of ore is delivered for smelting; much time and a large staff would be required. This was hardly necessary at Hardanger, where ores of fairly even contents without doubt could be obtained.

The price one should pay for the ore is, of course, regulated by the iron content and its adaptability for good smelting, and it is certainly not self evident that a cheap pig iron can be made from a cheap ore. There-

fore, the classification of the ore is governed by the actual results of smelting only, local conditions being considered as well.

Four different ores were used at Hardanger, namely, Klodebergs ore, "red sand" concentrate, and briquets from Sydvaranger, all from Norway, as well as ore from Persberg in Sweden.

These ores were used in proportions given in Table III.

TABLE III

Period	Ore	Per cent Fe in the ore	Per cent of ore charged	Pig iron produced in per cent of charge
Period I	Klodebergs ore .....	45	About 96	38.1
	Red sand concentrates ..	64.5	" 4	
Period II	Klodeberg ore .....	45	" 22	50.7
	Sydvaranger briquets ..	64	" 56	
Period III	Red sand concentrates ..	64.5	" 22	56.4
	Sydvaranger briquets ..	64	" 88.5	
Period IV	Red sand concentrates ..	64.5	" 11.5	44.6
	Persberg ore .....	53	" 56.5	
	Red sand concentrates ..	64.5	" 43.5	

The Klodeberg ore, which was used almost entirely during period I, and also to some extent during period II, contains about 0.3 per cent of zinc, and this caused a certain amount of difficulties at Hardanger; but apart from this, this ore is rather poor and therefore gives, as the table shows, a low output under period I, only 38.1 per cent.

Hence, if this ore is not exceptionally low in price, it appears to be rather unsuitable for a smelting operation in general.

The briquets from Sydvaranger are prominent on account of their high percentage of iron, and also low content of sulphur and phosphorus. They would, therefore, be regarded as particularly suitable for this process, but the price is so high that it is scarcely likely that it will be economical to use this ore as staple ore. It is, however, most suitable for enriching other poorer ores.

It was stated as a considerable disadvantage at Hardanger, that the briquets delivered were falling into smaller pieces and sand, but it is to be expected that this will be improved upon so that the briquets will arrive in a sound condition.

The red sand concentrate is also characterized by a high percentage of iron and low content of phosphorus, and as it probably can be obtained at a reasonable price, it should form a good staple ore. It has, however, the disadvantage that it contains a good deal of sulphur, wherefore roasting is necessary, and this, of course, increases the cost somewhat.

It was intended at Hardanger to roast this ore on the spot and to agglomerate it at the same time. This, however, met with difficulties; although the de-sulphurization was very effective, it was not possible to cause the ore to stick together to any great extent, wherefore it was necessary to charge the ore in a fairly divided state instead of in lumps as intended, and this, of course, caused a considerable alteration in the original smelting program.

In any case it should be possible to smelt a charge with a considerable percentage of concentrate, if no gas-circulation is used, probably even up to 75 per cent of total ore.

The author of the paper does not consider this fact to be a cause of the previously mentioned abandonment of the gas circulation; this is, however, not entirely out of question, as regards the second furnace, where a higher temperature was otherwise obtained, and Table III shows that a certain amount of this concentrate was used during that period.

In spite of the high percentage of Fe in both Sydvaranger and red sand ores during period II the output was, on account of the poorer Klodebergs ore, only 50.7 per cent.

During period III, when only Sydvaranger and red sand ore was used, the output increased to 56.4 per cent.

The reader may be reminded here that in the trial smeltings at Trollhättan and the Strömsnäs Iron Works, the yield was mostly higher, namely, about 62 per cent, and in some cases up to even 75 per cent.

It is, of course, easier to obtain a higher yield when the smelting is carried out with charcoal and a charge which does not require a large addition of lime, as compared with coke-smelting.

The Persberg ore was used during period IV in the second furnace. Although this ore is a good ore in itself, the author of the paper does not regard it very suitable for the case in question, and he gives the following reasons for this opinion.

In the first case, it only contains about 53 per cent Fe, and, secondly, it contains such a considerable amount of silicious matter that a large amount of lime is required to obtain a basic slag, such as is required with electric smelting. This is shown by the fact that although the ore was considerably enriched with the red sand concentrate, only 42 per cent pig iron (in per cent of charge) was obtained; besides the freight cost will no doubt be rather high.

It is, therefore, not said that this ore is unsuitable for electric smelting. On the contrary, where charcoal is used, and a very basic slag is not required, it should give good results if mixed with richer concentrates.

The author proceeds to show by example how important it is economically to use a charge with high percentage of Fe, and compares the results with different ores.

This comparison is best made between a modification of the conditions at Hardanger during period I and corresponding conditions for period III.

As only a smaller quantity of red sand concentrates was charged during these periods, one can regard period I as representing Klodebergs ore with about 45 per cent Fe and period III Sydvaranger briquets with about 64 per cent Fe. We may further surmise that the furnace in both cases is operating with gas-circulation and about 33 per cent CO<sub>2</sub> in the issuing gas without any difficulties, and that the apparent efficiency is 70 per cent. Under such conditions the output per year is represented by the upper curve in diagram Fig. 1. During period I, with a charge giving a yield of 38.1 per cent Fe, we should have an output of 2 tons, and for period III, with a yield of 56.4 per cent Fe, we should get 3 tons of pig iron, all calculated per hp-year.

If we assume a price of \$8.25 per hp-year (which is quite permissible), we find that power cost per ton of pig iron will be, in the first case, in round figures, \$4.12, and in the second case \$2.60.

Consequently, the price of electric power alone, per ton of pig iron made from the low-grade ore, is higher by \$1.50 as compared with the production of iron from the richer ore.

(The actual difference total is very much higher, which will be shown in Table X, which is given in the second part.)

Furthermore, during period I only 43.8 per cent of pig iron was produced from ore proper (this figure is rather low, if the analysis of the ore is considered), and in period III 69.1 per cent. In other words, in order to obtain 1 ton pig-iron one requires 2.3 tons of the low-grade ore and 1.45 tons of the richer ore.

If the extra cost of handling of the larger quantity of ore and slag are duly taken into consideration, as well as other expenses connected with the smelting of a larger quantity of low-grade ore, one is justified to conclude that for the case in question the Klodebergs

ore should only demand one-half, at the most, of the price of Sydvaranger briquets.

### Electrode Consumption

The consumption of electrodes at Hardanger, compared with other works, is shown in Table IV, where the consumption is given also for the works at Uddeholm and the before-mentioned furnace belonging to Strömsnäs Iron Works, both in Sweden.

TABLE IV.

Plant	Electrode Consumption in Kilogr.		
	Per ton pig iron	Per day, total 24 hrs.	Per 24, working hours
Hardanger, Period I.....	29.7	170	215
Hardanger, Period II.....	16.3	156	172
Hardanger, Period III.....	11.1	134	138
Hardanger, Period IV.....	41.84	439	510
Uddeholm, Furnace I, March 15- December 31, 1912.....	About 9.0	About 151	About 158
Uddeholm, Furnace II, August 4- December 31, 1912.....	7.0	135	141
Strömsnäs, Oct. 1-Dec. 31, 1912..	2.78	58	59

The heavy figure for period IV is stated to have been caused by an unusually bad delivery of electrodes, and the Electrometallurgical Committee states that the actual consumption of electrodes, after all breakage has been deducted, is only about 14 kg per ton of pig iron, instead of 41.84 kg. This would correspond to about 170 kg per twenty-four working hours.

As the author of the paper does not state anywhere of what capacity the furnaces were in either case, it is not entirely fair to draw a comparison between the plants, as a furnace of a smaller size will give a different figure compared with a larger, though, of course, the consumption per ton of pig iron is a deciding factor in all cases.

It is clear that the consumption of electrodes is greater when a lower-grade ore is smelted, which would perhaps explain the difference between the 14 kg for period IV and 11.1 kg for period III, when a richer ore was smelted, but on the other hand, the electrode consumption is greater when gas circulation is used, which would have had the opposite effect.

It may be presumed that the electrode consumption is increased when coke is used as reducing agent, and in this case the arrangement of the electrodes should be specially considered. This fact seems to be more or less proved by the frequent breakings of the electrodes at Hardanger.

As has been stated in another report, the furnaces at Hardanger carry six electrodes, as is also the case at Uddeholm, while Strömsnäs furnace has only four. The advantage of using six electrodes, which give a better distribution of heat, is obvious when coke is used. But as far as the experience now shows, the electrode consumption is hereby considerably increased.

The electrodes at Uddeholm and Strömsnäs have the same diameter as those in Hardanger, namely, 500 millimeters (about 19¾ in.) and as the power consumption does not differ considerably, each electrode has a much smaller working current density when six are used instead of four. In other words, at Hardanger as well as at Uddeholm, a larger electrode diameter than necessary for the energy supply has been used as compared with Strömsnäs, and the question arises whether the electrode consumption would not have been lower if electrodes of smaller diameter had been employed so that the current density per square inch had been the same as in the Strömsnäs furnace.

Sufficient data for a satisfactory reply to this question are at present not available, but the results from Strömsnäs are certainly significant though several causes must have added to the good results in that plant, for example, specially good quality of the electrodes and similar causes.

Luton, England.



## Fine-Meshed Brass Gauze as a Substitute for Platinum in Electro-Analysis

BY D. F. CALHANE AND T. C. WHEATON

The following article describes a successful substitution in several cases of electro-deposition of metals, of brass gauze as cathode in place of the ultra-expensive platinum. The methods of analysis that will be described have been given two years' tests in this laboratory and found to work well in the hands of students. A great deal has been published on rapid methods of electro-analysis using rotating electrodes and in some cases on methods where the torque of a magnetic field is employed to stir the solution and permit of large currents being used.\*

Among the first to notice the value of gauze for cathodes was Winkler in 1899, who stated that the use of platinum gauze as cathode in place of the cones, cut down the time to one-quarter, since large currents could be successfully employed.

Frary also made use of cathodes of platinum, silver and copper gauze in his solenoid apparatus. (Jr. Am. Chem. Soc., vol. 29, p. 1592.)

Stoddard (Jr. Am. Ch. Soc., vol. 31, p. 385) confirmed the work of the previous writers and held that with strong currents and no rotation the heat and gas evolution stirred the solution very adequately. This has been found to be true in our work.

It has been difficult to find a good substitute for platinum. Frary, as previously mentioned, used nickel, copper, and silver gauzes in the deposition of zinc.

J. W. Turrentine<sup>1</sup> proposed the use of graphite cathodes and anodes in place of platinum. These worked fairly well, but with high current densities the graphite is apt to flake and become porous. Sherwood and Allen<sup>2</sup> used a cathode of stamped tin in the determination of zinc, copper, silver, cadmium, and nickel.

Powock<sup>3</sup> tried mercury-coated zinc or brass gauze electrodes in the determination of zinc with favorable results. In our work a very fine brass gauze of 100 mesh to the inch was employed. It was copper-coated beforehand. The advantage of the brass gauze is that it is obtainable in finer mesh than copper gauze, and so, for a given size, presents more surface, permitting of large current and thus improving the time factor. Further, it is tougher and is comparatively the cheapest gauze that can be used. At retail its present cost is 80 cents per square foot, and this will make 6 electrodes of the size to be described. With proper care they last for a long while.

One set for a class can be discarded at the end of the term and the cost to each student is insignificant. One of these electrodes worth 20 cents has been used for 30 determinations of copper and is still in good condition.

### Preparation of the Gauze Electrodes

The brass wire cloth is cut into pieces  $5\frac{1}{4}$  in. long and  $3\frac{1}{4}$  in. wide. The longer edges are lapped over and hammered down. The shorter edges of the gauze are bent over a 12-in. loop of No. 22 copper wire, and the ends of the wire twisted together, thus forming a cylinder, weighing about 12 grams.

The gauze cylinder is placed in a caustic bath to remove grease, rinsed and then plated in a copper sulphate solution for a few minutes, using a current of 2 or 3 amp.

The gauze is then washed, dipped in alcohol, dried and weighed.

For ammoniacal solutions a platinum wire insert is used in the copper wire stem, which will otherwise be attacked by the ammonia fumes near the surface of the solution.

Only two pieces, each 3 in. long, of platinum wire are needed. These are attached to the brass gauze cathode and twisted together. Their other end is joined with the copper wire stem. The approximate area of one of these cathodes is 64 sq. centimeters, calculated from the formula  $S = 2\pi Deb\sqrt{n}$  (Winkler, Berichte, 32, 2192), where  $S$  is area,  $D$  is diameter of the wire,  $l$  is length of gauze strip and  $b$  is its width, or height of the cylinder, and  $n$  is number of meshes per sq. centimeter.

The area is not the whole factor responsible for the efficiency of the gauze, as a plain surface  $5 \times 3$  in. would offer nearly 97 sq. cm. surface. It undoubtedly lies in the nature of the surface of a gauze facilitating the rapid elimination of hydrogen, with large currents, thus giving a stirring effect and increasing the rate of migration near the surface of the gauze. Investigation of this problem will be carried out in this laboratory.

The procedures and results in the cases of copper, nickel, and zinc determinations will be given.

Analyses for copper were made from silver alloys, German silver, nickel-copper alloys and copper scale that was contaminated with iron and other impurities.

It was found in the case of silver and copper determinations in potassium cyanide solution that at low potentials between 2 and 3 volts for the deposition of the silver, the brass gauze could not be used as the zinc dissolved, and silver was deposited.

The potential separation of silver from copper in cyanide solution was carried out with platinum gauze and then the copper was deposited on brass gauze at 12-15 volts pressure and a current of 1 to  $1\frac{1}{2}$  amp. Time, one hour.

Wt. Cu. deposit	Per cent copper
0.012	9.11
0.0122	9.10

The procedure in the analysis of copper scale was as follows: About 0.75 gr. of the sample was dissolved in nitric acid. This solution was evaporated to soft dryness and 10 or 15 c.c. of water added. Then the acid still present was neutralized with ammonia and the solution then made acid with  $H_2SO_4$  and 4 drops of  $HNO_3$  added. The solution was diluted to 150 c.c. and electrolysed, using a platinum wire spiral as anode and the brass gauze as cathode. The spiral was made by coiling up 10-12 in. of thin wire weighing about 1 gram to the foot.

Some of the results obtained were as follows:

Wt. sample	Wt. deposit	Per cent copper
0.4628	0.3366	72.730
0.8292	0.6035	72.780
0.8097	0.5908	72.980
0.8428	0.6118	72.600
0.7710	0.5610	72.75
0.6781	0.4945	72.800

The current employed was 3 to 4 amp for the first ten minutes and 1 amp for  $\frac{3}{4}$  of an hour. A complete analysis could be carried through in  $1\frac{1}{2}$  hours. The deposits were excellent, bright and adherent. The above analyses were selected from the work of the Senior class in Chemistry.

Analyses for nickel were made from various materials, e. g., nickel-copper alloys, German silver, nickel anode scrap and resistance wire. In the analysis of German silver alloy, using the brass gauze cathode, it was found possible to deposit completely between 0.3 and 0.4 gram of copper in 45 to 50 minutes, using a current of 5 amp for seven minutes and 1 amp for 40 minutes.

\*Publications of Prof. Edgar F. Smith, Prof. Classen and their pupils. Smith's Electro-analysis.

<sup>1</sup>Trans. Am. Electro-chem. Soc., 15-505-17; 303.

<sup>2</sup>Tr. Am. Ch. Soc., 1907, 29; 1605-1074.

<sup>3</sup>Smith's Electro-analysis, 1911-119.

Wt. sample	Wt. deposit	Per cent copper
0.5040	0.3017	59.86
0.5045	0.3020	59.82
0.5000	0.2995	59.90
0.5052	0.3026	59.91
0.5076	0.3043	59.97

The following procedure was observed in the electrolytic determination of nickel using the brass gauze cathode: About 0.5 gram of the sample is dissolved in a 250 c.c. evaporating dish with 5 c.c. of nitric acid (sp. gr. 1.2). The dish is covered with a watch glass and finally heated on the steam bath when the metal completely dissolves. The solution is then evaporated to dryness. The residue is treated with 4 c.c. of sulphuric acid (sp. gr. 1.84) and heated over an iron plate to expel nitric acid. Twenty c.c. of distilled water are added to the cooled residue, and the dish heated to 60 deg. C. to dissolve all the sulphates.

In a tall 150 c.c. beaker the brass cathode and platinum wire spiral anode are placed and all connections made for a 1 amp current to flow.

The acid sulphate solution is neutralized with ammonia and 30 c.c. excess of strong ammonia added together with a solution carrying two grams of ammonium sulphate. This solution is poured into the 150 c.c. beaker through a funnel. The current starts at once and the metal is deposited on the gauze, thus preventing any solution of the brass cathode. The cell is now switched over on to a large rheostat and 4 amp allowed to flow for five minutes, which deposits the larger part of the nickel in this time. At the end of five minutes a current of  $\frac{1}{2}$  amp is switched on and allowed to flow for the rest of the time necessary to deposit the remainder of the metal. At the end a few drops of the solution are tested for nickel with  $H_2S$ . A flexible wire is attached to the cathode and this loosened from the binding post and raised slowly from the solution washing with a stream from the wash bottle. The lower edge of the cathode is finally raised from the solution, breaking the electric circuit. The electrode is immersed in distilled water, then in alcohol, and dried at 100 deg. C.

The following data gives results of analyses performed as just explained.

Wt. charge	Wt. deposit	Per cent Nickel
1. .05823 gr.	0.5129	88.08
2. .05919 gr.	0.5212	88.05

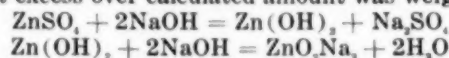
Gauze used	Wt. sample	Wt. deposit	Condition	Per cent Nickel
1. .Platinum	0.5983	0.5372	Good	89.80
2. .Brass	0.5474	0.4917	Good	89.82
3. .Platinum	0.4979	0.4368	Good	89.76
4. .Brass	0.5318	0.4797	Good	89.89

The first two analyses were of nickel drillings. The following four examples were analyses of borings from nickel anode scrap. The current was 4 amp for the first five minutes and  $\frac{1}{2}$  to  $\frac{3}{4}$  amp for the rest of time, averaging one hour for the maximum time. The deposit were in all cases bright and firmly adherent. It may further be seen that the brass gauze cathode gives exactly as good results as the expensive platinum.

In the zinc analyses a large number of determinations were made, using pure zinc, crystallized zinc sulphate and other zinc bearing material, as alloys such as German silver, impure zinc dust, etc. In all, over 30 determinations were carried out. The solution used was sodium zincate. It was prepared as follows:

The sample was dissolved in dilute nitric acid and then evaporated to dryness. The dish was then heated over an iron plate with 4 c.c. of strong  $H_2SO_4$  (Sp. gr. 1.84), leaving the zinc finally as sulphate. The residue

was moistened with a little  $H_2SO_4$  and taken up in 25 c.c. of water. The following equations show that 4 moles of NaOH are required for 1 part of zinc. A three per cent excess over calculated amount was weighed out.



It was found convenient to make up a solution of standard NaOH of  $2\frac{1}{2}$  to 3 normal strength and run in the desired number of c.c. to answer approximately to the calculation for amount of NaOH desired. Say .25 gr. zinc is present, then

$$160 : 65.4 : : x : .25 \text{ whence } x = 6.13 \text{ grs.}$$

of NaOH. Adding 3 per cent excess we have

$$6.13 \times .03 = 0.1839 \text{ gr.}$$

$$6.13 + .1839 = 6.31 \text{ grams of NaOH.}$$

Say the solution of NaOH carries .1 gram of NaOH 6.31

per c.c., then  $\frac{.1}{6.31} = 63.1$  c.c. of solution required.

.1

The gauze cathode and spiral anode were placed in a dry beaker, as in the case of nickel analyses, and the hot solution of zincate poured in through a funnel, the current starting to flow at once. A film of zinc is at once deposited on the surface of the gauze and oxidation prevented. The end of the zinc precipitation may be ascertained by attaching a clean copper wire to the cathode binding post and immersing the end in the solution. If no zinc covering appears after a reasonable time the precipitation is considered complete.

The following are the results of some of the analyses for zinc:

Wt. substance	Cathode	Wt. deposit	Con- dition	Solenoid	% zinc
1. .1.1626	Brass gauze	0.2768	Good	.....	23.817
2. .1.0449	grs. "	0.2488	Good	rotated	23.81
3. .1.0394	" "	0.2476	Good	rotated	23.82
4. .1.1429	" "	0.2720	Fair	rotated	23.80
5. .1.1429	" "	0.2720	Good	not rotated	23.80

The stated amount of crystallized zinc sulphate was weighed out in each case  $ZnSO_4 \cdot 7H_2O$ .

In analyses 2-3-4 the solution was stirred by the magnetic field. In 1 and 5 no stirring was employed.

In analysis No. 1 the time was 25 minutes, 5 amp for the first five minutes and 1 amp for 20 minutes.

In No. 2—magnetic stirring—time 35 minutes, 4 amp 15 minutes and 2 amp 20 minutes.

In No. 3, 40 minutes with stirring, 4 amp 10 minutes, 2 amp 20 minutes, 0.5 amp for 10 minutes.

In No. 4—the time was 32 minutes, using magnetic stirring—4 amp for 2 minutes and 0.5 amp for 30 minutes.

In No. 5, no magnetic stirring, time 32 minutes, 4 amp for 2 minutes and 0.5 amp for 30 minutes.

From the results in analyses 4 and 5 it is seen that the magnetic stirring by solenoid does not materially hasten the deposition or improve the character of the deposit.

With the zinc analyses the best procedure was found to be a temperature for the solution of about 60 deg. C., a current of 4 amp for first 5 minutes and 1 amp for rest of time. For an average weight of deposit of 0.3000 gr. of zinc 4 amp for 5 minutes and 1 amp for 35 to 40 minutes was sufficient. The deposits were light-colored, non crystalline, and firmly adherent.

### Summary

It has been shown that the fine-meshed brass gauze is just as efficient as the platinum gauze.

That the time factor for the brass gauze with still electrolyte is very nearly as good as the platinum gauze with magnetic stirring. In fact, the difference in favor of the magnetic stirring is almost negligible.



The brass gauze has been successfully used in the electrolytic determination of copper, zinc, and nickel in various alloys. It gives a very cheap substitute for platinum, costing on the average only about 30 cents per electrode as compared with \$19 for a similar platinum electrode at the present price of platinum.

Investigations as to the use of the fine-meshed brass for the determination of other metals will be continued in this laboratory.

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## Concentration of Carnotite by Wet and Dry Methods

A year or more ago, when the carnotite deposits of Colorado and Utah began to attract considerable attention, a number of investigators realized immediately the desirability of effecting a physical concentration of the ore. The comparatively low grade of the ore, the distance from market and expense of transportation, pointed to this necessity. It was not surprising that practically all of the individuals engaged in this work hit upon similar schemes for concentration, but no publicity was given their methods at the time for the reason that they desired to keep them secret.

A little later the Bureau of Mines began an investigation of the deposits to ascertain their value and extent, and the methods of mining and treatment. *Bulletin 70*, recently issued by the Bureau, contains a preliminary report on uranium, radium and vanadium, and gives considerable information on the subject that has not been published hitherto. In addition to describing the deposits and giving the production and prices, the *Bulletin* gives information on methods of testing for radioactivity, and a review of methods of treatment and analysis. R. B. Moore and K. Kithil are the authors of the *Bulletin*.

The carnotite ores mined and shipped contain between 2 and 3 per cent  $U_3O_8$  and several per cent  $V_2O_5$ . The ratio of radium to uranium in carnotite is about 10 per cent below the normal, which is 1 part radium to 2,940,000 parts uranium. The methods of concentration and results obtained by the Bureau are given below.

### Necessity for Concentration

In the course of investigations of these uranium and vanadium ore deposits it was found that much low-grade ore was left in the mines, and thus lost, and that there was great loss in hand sorting. Since the market demand is for a material containing at least 2 per cent uranium oxide, the miner, that he may ship no ore below this limit, eliminates all ore that in his opinion contains less. As a result much low-grade ore and also some shipping ore are left in the mine or are thrown on the dump. By concentrating the low-grade ores at or near the mine these wastes can be reduced. There is no doubt that the ores can be concentrated. Tests made on a small scale substantiate this statement.

In concentration by mechanical means the dry as well as the wet method may perhaps be used to advantage, as little or no water is available in many places where these ores occur. As formerly stated, most of the deposits are far from a railroad, so that wagon hauls are long and expensive. By concentration the bulk of low-grade ore to be hauled can be reduced and at the same time the percentage of mineral in the concentrate raised to a marketable point. Thus a saving in hauling and freight rates is effected, and the concentrate on account of being richer should bring a better price. Low-grade ores thrown on the dump or left in the mine constitute a natural waste. Much of the low-grade material left in the ground during former operations and perhaps

much of the dump material can never be recovered. Much of the ore thrown on the dump disintegrates on exposure to the air, so that much of the valuable contents is washed or blown away. Some of the minerals in the dump rock are liable to be leached out by the rain.

### Wet Concentration

The carnotite ores are of great importance, especially on account of their uranium and radium content. Carnotite, which contains both uranium and vanadium, is a yellow, crystalline, pulverulent material, with a specific gravity of 4.136. It occurs in white sandstone as an incrustation on the faces of joints and fractures and is deposited around and between the individual grains of the sandstone, often strongly adhering to the even surface of a grain. The size of these grains varies greatly, but is generally from a little less than 0.1 to 0.2 mm. in diameter.

In concentrating such an ore the rock should be broken and the pieces reduced to about 40 to 80 mesh with crushers or rolls, the crushing being accompanied by rubbing in order to loosen the carnotite from the sand grains. Further attrition should be applied to the 40-mesh material by convenient means. Fine grinding should be avoided, as it produces too much slime.

If the crushed and rubbed material is washed in a revolving tank or trommel provided with a rubbing device, the particles of carnotite that are in suspension can be drawn off after the grains of silica have settled in the tank or cylinder. As some of the carnotite is carried down by mechanical action with the silica in settling, more water should be added and the operation repeated as many times as may be profitable. With such a treatment a large part of the valuable minerals can be extracted.

The slime is washed into settling tanks or other suitable device, and the water after the settling of the slimes can be used over again, as will be necessary in the arid districts, where most of the deposits are located and where water is scarce. Enough water can be collected and stored away for this purpose from seepage, springs, and during rainy days, and in many cases a wet treatment can in this way be made possible.

### Results of Wet Concentration Tests

Tests have been made of ore taken from the dumps at various claims. In one instance this ore contained 2.02 per cent  $U_3O_8$  and 2.32 per cent  $V_2O_5$ . Concentration by wet method gave the results stated in Table I:

Table I—Results of Concentration by Wet Method

	Quantity, Grams	$V_2O_5$ , Per cent.	Weight of $V_2O_5$ , Grams	$U_3O_8$ , Per cent.	Weight of $U_3O_8$ , Grams
Ore .....	1,943	2.32	44.08	2.02	39.348
Concentrate .....	191.3	9.92	18.976	8.84	16.91
Residue .....	1,751	.....	.....	.....	.....
	1,942.3	.....	.....	.....	.....

Loss in concentration, 0.7 gram. Concentration ratio = 10.156 : 1. Extraction from ore by concentration,  $V_2O_5$  = 43.035 per cent.;  $U_3O_8$  = 43.08 per cent. Ratio of ore to concentrate, vanadium content = 1 : 4.275; uranium content = 1 : 4.376. Ratio of radioactivity, measured in the electroscope, ore to concentrate = 1 : 4.56, which shows that the concentrate is 4.56 times more radioactive than the ore.

Other tests made with ore containing less  $U_3O_8$  and  $V_2O_5$  have shown that an extraction can be made with a proportionately similar result.

Table II—Result of Concentration of Vanadium-bearing Sandstone by Wet Method

	Quantity, Grams	$V_2O_5$ , Per cent.	Content of $V_2O_5$ , Grams
Ore .....	400	5.57	22.28
Concentrate .....	85	17.35	14.75
Residue .....	315	.....	.....

Concentration ratio = 4.72 : 1. Extraction = 66.2 per cent.

The result given in Table II was obtained with a reddish-brown vanadium-bearing sandstone from Utah.

The ore was crushed to the size of the grains, rubbed, and then washed in cold water. The slimes thus obtained were settled and decanted or filtered.

According to electroscopic measurements, and by comparison with a standard material of known  $U_3O_8$  content, it was found that this ore contained approximately 0.71 per cent  $U_3O_8$  and the concentrate contained 1.62 per cent.

In concentrating this vanadic sandstone the content of vanadium was therefore raised to 17.35 per cent  $V_2O_5$  and the concentrate can be sold in competition with the Peruvian patronite. In addition the uranium and the radium can be easily extracted from this ore. Some of the vanadium can not be extracted mechanically; it probably exists in the sandstone as roscoelite, which is bound in the silica.

#### Dry Concentration

Where water is scarce a dry process can be adopted for low-grade ores. As good concentration with a dry as with a wet process can not be expected, but an equally efficient if not a better extraction can be obtained.

In a dry process the rock should be reduced with crushers and rolls as nearly as possible to the size of the grains of the sandstone. Much of the carnotite can be obtained by sifting the crushed material through a 120 to 150 mesh screen. Care must be taken to collect all of the dust, as this is richest.

Good results can be obtained by using an air current to blow the finest particles into a dust chamber, in which they are collected. The air current must be steady and evenly expanded, so that the coarse particles will drop out of it, and strong enough to completely lift the material. The coarse material should be carried along with the current for some distance, so that as much as possible of the powdery material can be freed and blown from the coarse grains, which should finally drop without carrying the powder with them. These particles should fall into a discharge spout and thence into bins or other suitable devices. The powdery materials, which carry the valuable minerals, is collected in dust chambers. These chambers must be perfectly tight. Much valuable mineral has been lost in sampling shipments when the sampling device had no arrangement for saving the dust.

A number of machines that doubtless could be used for the dry separation of these ores are now on the market. Another method of dry concentration of low-grade ores consists of simple sifting, with previous rubbing, of the crushed ore. The ore is reduced with crushers and rolls to about 40 mesh and is then passed over an oscillating 150-mesh screen. The undersize from the 100-mesh screen is concentrate. The oversize is carried to a device in which the sand grains are subjected to a thorough rubbing, which removes from the silica the adhering fine particles of carnotite.

Table III—Results of Dry Concentration by Sifting with Previous Rubbing

	Mesh of sieve	Quantity, $V_2O_5$		Weight $U_3O_8$		Weight
		Grams	Per cent.	Grams	Per cent.	of $U_3O_8$ , Grams
Ore	40	500	2.40	12.25	2.24	11.20
Concentrate, Under 150		134	4.66	6.24	4.42	5.92
Residue, Over 150		169	1.60	2.70	1.53	2.58
Residue, Over 80		197	1.50	2.95	1.37	2.68
		500		11.89		11.18

Concentration ratio—ore: concentrate—3.73 : 1; extraction  $V_2O_5 = 50.85$  per cent; extraction  $U_3O_8 = 52.85$  per cent.

In the experiment stiff wire brushes rubbing against a steel plate were used with success for the attrition. The entire material was then brought over two screens, one overlying the other; the upper screen being 80 mesh and the lower one 150 mesh. Table III clearly shows what results can be obtained by such a process. The

screens must be encased and all of the dust must be collected. The dust from the sifting operation and that which remains in suspension in the dust-proof screen boxes can be blown from these boxes by suitable means into dust chambers and then added to the concentrate.

A concentration by this dry method on a small scale gave the results shown in Table III. Care must be taken in crushing the ore for either wet or dry concentration that little, if any, of the dust-like material is lost. Dust chambers should be attached to the crushers, or the latter should have air-tight casings and the material should not be removed until the dust has settled.

#### Cost of Concentration

The factors to be considered in a calculation of the cost of concentrating the ore by a wet method are:

1. Cost of concentration: (a) Water supply; (b) Cutting wood for fuel for power and drying (or cost of gasoline if that is used for fuel); (c) Hauling of fuel or gasoline; (d) Wages for concentrator men.
2. Amortization of equipment for concentration (pro rata of tonnage of material treated per annum for such equipment and for management).

Two men, at \$3 a day each, should be able to operate a small plant. The cost of water supply should not exceed \$2 a day. The cutting of fuel or cost of gasoline should not be more than \$2 to \$2.50 a day. The hauling of the fuel would probably cost \$1.50 a day.

On an average, from 10 tons of ore mined only 1 ton of ore with a content of over 2 per cent  $U_3O_8$  is obtained by hand sorting. From the other 9 tons, thrown on the dump, about 5 tons of low-grade ore can be separated for concentration. Assume that such low-grade ore contains, on an average, about 1 per cent  $U_3O_8$  and 1.5 per cent  $V_2O_5$ . With a concentration ratio of 10 to 1, half a ton of shipping ore should be obtained. The total extraction of mineral by a wet method should be about 50 per cent, and the grade of the material obtained would therefore be fairly high. In an actual test on such a low-grade ore the percentage of  $U_3O_8$  in the concentrate was found to be about 4.5. This should, of course, command a proportionately higher price.

The cost of concentration by the dry process is approximately the same, less the cost of the water supply.

The cost of concentration, including maple charges for amortization and for management, should not exceed \$20 per ton of concentrate. These figures are conservative and probably the ores can be concentrated more cheaply.

The average cost of mining with present methods at the rate of 10 tons of ore a day with 6 men and the hand sorting done by the foreman is about \$30 per ton of shipping ore. This figure does not take into account the powder used in blasting, the wear of tools, etc. If the grade ore is utilized by means of concentration, the expense of mining is thereby increased little, if any, and only the additional cost for the concentration has to be taken into consideration, the charges for sacking and hauling the concentrate to the station being the same as for a ton of ordinary ore.

From the above it will be seen that through utilizing the low-grade ores the average tonnage per year could be increased 50 per cent with little extra expense. But as the uranium and vanadium content of the concentrate would be at least double that of the average ores shipped, the total production of uranium and vanadium from these ores would be doubled. For various reasons it is hardly to be expected that all of the waste material can be utilized, and therefore such a large increase will probably never be actually obtained.

Perhaps several of the operators could combine and install an equipment for mechanical concentration and treat their low-grade ores in a central plant, especially



where several operators are in the same district and the claims are near each other. With such a plant in use the production of marketable ore at the present rate of mining could be increased by about one-half without increasing the cost of mining and with only the additional expense of concentration. This increase can be obtained by treating material that hitherto has been lost.

The assumption, which has been made by many of the dealers, that by concentration a large part of the radium content of the ore would be lost, is entirely without foundation, as no such losses of radium in the concentrate can occur from any mechanical treatment of the ore. This has been proved by the tests of the concentrates. Undoubtedly the statement has reference to chemical concentration, in which, of course, such losses might occur.

### The Power Problem in the Electrolytic Deposition of Metals

A joint meeting of the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, and the New York Section of the American Electrochemical Society was held in the Engineering Building on the evening of January 9, 1914, President Mailloux of the American Institute of Electrical Engineers being in the chair. Each of the three societies was represented by a paper, Mr. Lawrence Addicks defining the electrochemical problem, Mr. F. D. Newbury discussing the electrical engineering side of the problem, and H. E. Longwell the mechanical side.

#### The Power Problem in Electrolytic Refining of Copper

This was discussed by Mr. Lawrence Addicks, Superintendent of the U. S. Metals Refining Company, Chrome, N. J. By far the larger proportion of the world's copper is electrolytically refined, and this work is almost exclusively an American industry, centered chiefly in large plants on New York Harbor. These plants are being steadily extended as the annual production of copper increases, and present a power problem well worthy of special attention.

For a copper refining plant we have the following power limitations imposed by present practice:

- (a) Direct current.
- (b) Say 8,000 to 15,000 amperes.
- (c) Say 100 to 200 volts per circuit.
- (d) Resulting in 800 to 3,000 kw. units—1,000 to 1,500 in present installations.
- (e) Circuits electrically independent, to avoid cross leakage.
- (f) Constant current; somewhat variable voltage—say  $\pm 20$  per cent.
- (g) Steady current load night and day.
- (h) Steam needed for heating electrolyte.
- (i) Plants of from 3,000 kw. to 9,000 kw. should be considered.

The reasons for these limitations are as follows:

- (a) *Direct Current:* This is obviously required by the nature of the process.
- (b) *Amperage:* This is fixed by the current density and the electrode surface per tank. (This paper considers only the so-called multiple system of refining, where the electrodes in a tank are in multiple and the tanks on a circuit in series.) The current density is fixed by a balance between the interest on copper tied up, the cost of power and the difficulties in practical handling of rough deposits.

Fig. 1 shows the approximate relation between cost of power and current density in American practice; the high densities, of course, call for cheap water power. Twenty amperes per square foot of active cathode sur-

face may be taken as representing practice in the vicinity of New York, with an ampere efficiency of 90 per cent and an average consumption of about 1 kw. hour at the switchboard per 6 lb. (2.7 kg. of copper).

Electrode surface per tank has been steadily increased until 30 pairs of electrodes, three feet (90 cm.) square, are used in one case. This calls for a current of  $30 \times 3 \times 3 \times 2 \times 20 = 10,800$  amperes. It is conceivable that higher densities and longer tanks may come into use, so that the author has placed the practical limit at 15,000 amperes, but 10,000 amperes should be taken for a definite discussion.

(c) *Voltage:* As we have to deal with a highly conducting electrolyte, containing 10 to 13 per cent of free sulphuric acid, which must be continually circulated to avoid stratification in the tanks, carefully studied construction is necessary to avoid serious trouble from leakage currents. These not only represent wasted energy, as shown by the so-called current efficiency, but wherever current jumps from the electrolyte to a lead pipe or other metallic conductor, a rigidly equivalent quantity of copper is deposited thereon and when traversing acid-soaked wood of relatively high resistance, a quantity of heat sufficient to cause a fire risk may be generated. It must be remembered that nearly the entire electrical energy produced at the generators appears as heat in the tanks. It can be readily appreciated that high voltages greatly aggravate these difficulties. While the author has suggested 100 to 200 volts as the range per circuit, he favors the lower limit and does not believe voltages higher than 150 to be good practice.

(d) *Kilowatts:*  $10,000 \times 150/1,000 = 1,500$  kw. for our typical case. This is a little larger than most of the units at present installed, but represents the probable size for a new installation.

(e) *Circuits:* The statements already made regard-

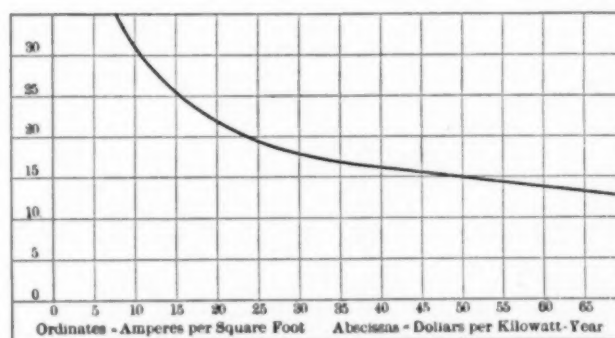


FIG. 1—RELATION OF CURRENT DENSITY AND COST OF ENERGY

ing current leakage indicate the undesirability of any electrical connection between generators, and the author believes it would be necessary to use motor-generators instead of rotary converters in any A.C.—D.C. scheme distributing power from a large unit over several circuits.

(f) *Uniformity:* The first principle to be observed in the operation of an electrolytic refinery is uniformity of conditions. The process is very delicate and, while simple in theory, economy depends upon the successful balancing of many conditions to obtain the best results.<sup>1</sup>

In consequence, the current should be held at a fixed value, following variation in the resistance of a circuit with the voltage. Hand control of the field of shunt wound generators is adequate, as the changes in resistance are very gradual. An exception to this statement is the case of cutting out sections of tanks for several

<sup>1</sup> Transactions American Electrochemical Society, 5, 119 (1904).

hours when drawing copper. It is also necessary to carry up to 2 per cent insoluble-anode tanks, to correct the gradual accumulation of copper in the electrolyte, and as these require about six times the normal voltage for operation, they cause an appreciable variation in the total resistance of the tank house when they are added or withdrawn. To cover this range a field control of our typical generator from 120 to 180 volts at 10,000 amperes will be required. Of course, there will be times when partial or excessive loads will be carried to meet slack or congested supplies of copper, but these conditions are not normal and need not be met with economy.

(g) *Load factor:* The operating conditions as described amount to practically 100 per cent load factor for both momentary and 24-hour loads.

(h) *Warming electrolyte:* Electrolytes have a high positive temperature coefficient of conductivity. As this amounts to about 0.5 per cent per degree F. (0.9 per cent per 1° C.) and as the electrolyte represents about half the ohmic resistance of the circuit, it is evident that its temperature must be considered. In general, the electric energy dissipated in the tanks will maintain a temperature of 90 to 100° F. (32°-38° C.) and it has been found economical to add sufficient steam in closed coil heating tanks to keep the circulating electrolyte at an average temperature of about 130° F. (54° C.). Exhaust steam can be used, and roughly an amount equivalent to one-fourth of the steam supplied to the engines is required. Additional steam is required for light and power, compressed air, pumping and the manifold requirements of a refining process of which electrolysis is but one step, so that figuring for the moment on the use of live steam for heating the electrolyte, only about one-half the total boiler capacity is used for electrolytic power generation. On the other hand, waste heat boilers attached to the reverberatory furnaces which form a necessary part of every refinery will generate more than enough steam for heating the electrolyte, etc.

(i) *Size of plants:* American copper refineries vary from 4,000,000 lb. to 35,000,000 lb. (1,800 to 6,000 metric tons) monthly capacity. At 6 lb. (2.7 kg.) per kw. hour our 1,500 kw. generator would take care of 6,500,000 lb. (3,000 metric tons) per month. Eliminating the smaller plants and allowing for some future extension of the larger ones, we should consider from 2 to 6 circuits of 1,500 kw. each, or 3,000 kw. to 9,000 kw. equivalent to from 13,000,000 to 39,000,000 lb. (6,000 to 17,500 metric tons) copper per month.

Turning now to present practice in the vicinity of New York, we find a very cheap source of fuel in No. 3 anthracite "buckwheat" at \$1.75 per long ton (\$1.715 per metric ton) delivered. Using this fuel, steam can be produced for about 15 cents per 1,000 lb. (33 cents per metric ton), including all operating expenses, but excluding administration, taxes, depreciation and interest charges. With this base price for steam, a kilowatt hour can be safely figured at 0.4 cent on a similar basis, allowing for auxiliaries and a reasonable departure from ideal conditions in everyday operating. In fact, 0.3 cent can be approached with first-class conditions.

Present practice is to use moderate superheating and vacuum, with the highest-grade reciprocating engines. At the Raritan Copper Works four-cylinder Nordberg triple expansion engines have recently been installed, while at the Chrome plant of the U. S. Metals Refining Company a triple expansion unit using a compound Hamilton-Corliss engine with a Rateau turbine for the third expansion is being tried out. Previous installations have been chiefly confined to compound condensing units. Final figures for these recent installations are not yet available, but Fig. 2 shows about what can be expected from a 1,200-kw. unit of each type, excluding steam for operating condenser.

The Chrome installation is of particular interest on account of the successful commutation of 6,000 amperes (the engine-generator and turbo-generator running in parallel) at 1,500 revolutions per minute by a Rateau-smoot generator.

The installation cost of such power plants may be roughly taken at \$100 a kilowatt, including the disproportionate boiler equipment and auxiliaries.

The plant of the future may consist of gas-driven units, of large-capacity alternating-current turbo-generators driving motor-generators of smaller size, of compound reciprocating engines exhausting into a trunk main from which exhaust steam turbines are fed, of multiple expansion reciprocating engines, of turbine-driven unipolar generators, or of some combination of these. Spare units must be provided in sufficient proportion to give absolute reliability of service.

### Prime Movers for Electrolytic Generators

In his paper on the mechanical side of the power problem in the electrolytic deposition of metals, Mr. H. E. Longwell, consulting engineer with the Westinghouse Machine Company, of East Pittsburgh, Pa., said he would confine himself to a general comprehensive survey of the problem from the hilltop of common sense. "In dealing with any technical problem, common sense is most useful; common sense combined with special

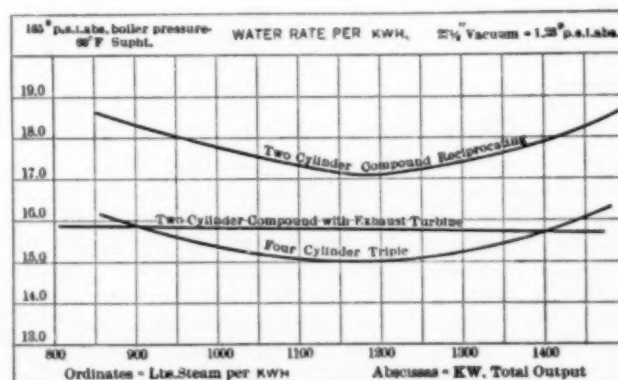


FIG. 2—WATER RATES OF VARIOUS PRIME MOVERS

technical knowledge is doubtless better; but technical knowledge without common sense is disastrous."

Mr. Longwell pointed out that any engine the exhaust steam of which is fully utilized can be considered as operating at 100 per cent efficiency. Comparing the performance of a steam-turbine plant with a gas-producer installation, each made up of 1500-kw. units and operating at high load-factors, the author estimated that, using a good grade of fuel containing 14,500 lb.-Fahr. heat units per lb., the gas-producer plant would probably show a saving of ½ lb. of coal per kw.-hr. over the consumption of the steam-turbine station. With coal at \$3 per ton, this saving of 2 tons per year would effect an economy of \$6 per kw.-year, to gain which an extra investment of about \$50 per kw. would have to be made over and above the cost of the steam-turbine plant.

Making annual allowances of 8 per cent for interest, 1 per cent for taxes, 1 per cent for insurance, 2 per cent for maintenance and 8 per cent for sinking fund, 18 per cent would be required to insure a return on the investment. As 20 per cent would be desirable, Mr. Longwell pointed out that the saving of \$6 per kw.-year effected by the gas-producer units could not be justified unless the differences in initial cost were \$30 or less per kw. of installation.

Although it is common practice in copper-refining plants to allow 50 per cent of the steam for the main



generating units, 25 per cent for the auxiliaries and 25 per cent for heating the electrolyte, the author declared that since the auxiliaries extract but little useful heat from the live steam, their exhaust can be used advantageously for heating, so that the entire amount for auxiliaries and heating need be only about one-half that required for the main prime movers. In the case of one copper-refining plant which he cited as turning out 500 tons per day the waste heat from the flue gases of the reverberatory furnaces alone is capable of furnishing 50,000 lb. of steam per hour. This steam represents about 40 per cent of that required to run the entire plant and is sufficient for all the requirements of the auxiliaries and the heating of the electrolyte.

Commenting on the theoretical advantages of arranging reciprocating compound engines to exhaust into low-pressure turbines, Mr. Longwell pointed out that the low-pressure turbine costs about 75 per cent more per kw. than the complete-expansion unit. Few triple compound engines, he thought, are enough better than two-cylinder units to make the addition of the intermediate cylinder worth while.

The development of a highly efficient transmission gear for turbines has now made possible the efficient turbo operation of direct-current generators. Several of these geared sets have already been in continuous service for several years, the best known examples being those at San Diego, Cal., Cleveland, Ohio, and Louisville, Ky. While a turbine-driven direct-current unit is more expensive than an equivalent direct-current alternator, it is nevertheless cheaper, said Mr. Longwell, than the combination of turbo-alternator and rotary converter advocated by another speaker.

With careful supervision a really good turbine-driven plant of 6,000 kw. to 9,000 kw. should be built for about \$75 per kw., "more or less." Burning coal at \$3 per ton and allowing 10.5 per cent for investment charges, it should be possible with capable and reasonably economical management and careful operation at 100 per cent power-factor to produce energy at the switchboard for 4.3 mills per kw.-hr., "more or less."

#### Electrical Equipment for Electrochemical Processes

The electrical side of the power problem was discussed by Mr. F. D. Newbury, of the Westinghouse Electric & Manufacturing Company, in a paper on "sources of direct current for electrochemical processes."

The problem involved in producing direct current for electrochemical processes was outlined, and the difficulties are pointed out.

Of the methods of power supply using steam turbines that are available, it was shown that:

(a) Direct-connected d-c. turbo-generators are available only in relatively small units, and cannot be designed as conservatively from the commutation standpoint as is desirable.

(b) Unipolar generators driven by turbines have proven unsatisfactory on account of current collection difficulties.

(c) The standard medium-speed d-c. generator connected to a high-speed turbine through gearing affords a satisfactory unit.

(d) The combined a-c. turbo-generator and converter unit probably affords the best all-around method. It is economical, reliable and flexible. Its particular fields of application are where large units and long transmissions are required.

In waterpower plants, direct-connected d-c. generators and a-c. generators with converters are available. The combined a-c.-d-c. equipment is usually the most reliable and economical. With reciprocating engine units there is no reason for considering other methods than the direct-connected slow-speed generator.

#### Discussion

The three papers were discussed together and the discussion was extended, lively, and interesting. Besides President Mailloux, there participated in the discussion Messrs. F. L. Antisell, H. B. Coho, J. B. Herreshoff, J. B. Herreshoff, F. A. Lidbury, C. A. Roush and C. H. vom Baur.

Mr. F. A. Lidbury said that a plant having an ultimate capacity of 120,000 hp., mentioned by one of the authors, was hardly typical of ordinary electrochemical industries. Only for the manufacture of aluminium are such plants conceivable at the present time. Most electrolytic plants of importance, the aluminium industry being excepted, have a power consumption somewhere between 1000 hp. and 10,000 hp. The electrochemist does not consider it prudent to put, if he can help it, all his eggs into one electrical basket, and consequently in even the largest electrolytic installations (still excepting aluminium plants) the size of units does not often exceed 1000 kw. Under such conditions the conclusions will be different from those reached for a 120,000-hp. plant.

For instance, Mr. Lidbury said, it will no longer be correct to say that "in very few plants can water-wheel generators be located near enough to the electrochemical plant to justify the installation of direct-current generators." It is obviously true that where transportation or other conditions demand the location of the electrolytic plant at a considerable distance from the powerhouse, direct-current generation will be out of question in any case, but where no such condition is involved, it will usually be found not only feasible but the only rational scheme. Mr. Lidbury showed in some detail why for ordinary electrochemical plants he considered direct-current generation quite feasible instead of alternating-current generation with rotaries. "The electrochemical engineer is also apt to have an absurd prejudice in favor of simplicity, and occasionally has been known to evince an unaccountable willingness to pay for it. But there are good reasons for this. Generally speaking, he has quite enough operating troubles of his own without desiring to assume, in addition, the operating troubles of a central station superintendent. What he wants in the way of power equipment is something which will be primarily characterized by smoothness, ease and reliability of operation, and he is apt to know by experience that this is not most likely to be obtained by multiplying the electrical links in his chain of power machinery, or the number of points needing continual attention to insure the best operating results."

Mr. F. L. Antisell, of the Raritan Copper Company, said that the efficiency at partial loads should not be overlooked, and called attention to the high operating efficiency of reciprocating engines at partial loads as compared with turbine units.

Mr. J. B. Francis Herreshoff, the distinguished engineer and metallurgist of the Nichols Copper Company, said they had had quite a varied experience. Their system at first apparently required small units, and these were supplied with high-speed triple expansion engines, of 400 kw. While they were satisfactory, the cost of maintenance was high. Later on they used a couple of 2000-kw. turbine-driven unipolar generators, but they showed a heat loss of some 30 per cent. Then his nephew, Mr. J. B. Herreshoff, conceived the novel idea of employing a low-voltage alternating-current generator, the output of which was rectified, without voltage transformation, by a properly designed rotary converter. The idea did not at first meet with favor among the engineers of the large electrical manufacturers, but was finally accepted and a good many of these machines are now in use for this type of work.

Mr. J. B. Herreshoff, who followed his uncle on the floor, said that by doubling the current density twice the amount of copper will be deposited in a given time. This requires double the voltage and thus four times the power, but has the advantage that the electrolyte is automatically kept warm without the use of steam. Although the power requirement is quadrupled, the cost per pound of copper is only doubled. But the objection to the use of this method in electrolytic copper refining is that the deposits are not so smooth, but are apt to be crystalline, more brittle, and this is often a serious matter in handling the cathodes.

President C. O. Mailloux said that the statement that the character of a deposit depends upon the current density is true in the sense understood by the speaker, but that as a general proposition it needs some qualification. As a matter of fact, it is possible to obtain good copper and bad copper at any current density from 10 to as much as 1000 amperes per square foot. He had worked this matter out in 1885, when he had to solve the problem of producing electrotype shells at an extremely rapid rate. Even with a current density of 500 to 1000 amperes per square foot beautiful deposits are obtained, if careful attention is paid to the solution, means of circulation, control of temperature, etc.

Dr. Mailloux finally explained the paradox that with a given amount of electrical energy it is possible at least in theory to deposit any amount of copper. The proof is based on the facts that the e. m. f. required is practically the voltage drop due to resistance only and that the weight of deposit depends only on the ampere-hours. Let a number of ampere-hours pass through a single electrolytic cell, then we will get a certain deposit. Now, let us use four identical cells, arranged in two sets in parallel, each set containing two cells in series, and let the voltage at the terminals of the whole system and the current passing through the whole system have the same values as before. Then the current density is reduced to one-half the former value in each cell. The deposit obtained in the same time is twice the deposit obtained in the former case, while the energy (watt-hours or volts  $\times$  ampere-hours) is exactly the same as in the former case. Now this multiplication of cells may be carried on in the same way further and further, but a point will finally be reached when, although very large deposits are obtained with the given energy, yet the area of plant required and the interest costs on the large amount of copper tied up would prevent the economical use of any lower densities.

Mr. Lawrence Addicks, in speaking on the effect of current density, said that the higher the current density the more rapid must be the circulation in order to keep saturated copper solution close to the cathode, as this is the secret of good deposits. But in the rapidity of circulation the copper refiner is limited by the necessity of keeping the silver and gold slime at the anode, without stirring it up and fouling the cathode. Mr. Addicks also put in a good word for the reciprocating engine driving a direct-current generator as against the turbine, with its alternating-current generator, transformer, rotary converter and booster.

Mr. C. H. vom Baur discussed the possibilities of oil engines for electrochemical purposes. Oil from fields recently discovered in Mexico can be sold in New York, he said, for less than 3 cents a gallon, so that such engines can produce a kilowatt-hour for 0.45 cent.

Mr. Addicks in closing the discussion pointed out that the oil engine employs a fuel which, compared with coal, is in the hands of a small selling group, and

he also questioned whether such internal-combustion engines have the reliability necessary for electrolytic work.

Mr. Longwell said that the gas engine has a great many uses to which it is eminently suited, but in a wholly impartial way he did not think that electrolytic plants were included among these.

Mr. Newbury explained as the reason for selecting very large plants as examples his efforts to show that in such sizes the converter apparatus recommended is really simpler, more reliable, more efficient, and less costly to maintain than the apparently simpler installations consisting of merely prime mover and generator. In sizes of 1000 kw. to 2000 kw. he admitted the turbo-alternator and rotary-converter cannot make a showing against the direct-current generator, provided the electrolytic plant is located near the place of generation.

After the meeting there was a most enjoyable smoker tendered by the American Institute of Electrical Engineers.

### Notes

**Dunn Powdered Coal Burners.**—In connection with the article by Professor G. A. Roush in our January issue it is interesting to note that the Dunn burners have been installed in seven cement plants, four in the East, two in the West, and one in Germany. They are being used by the Carolina Ore Company, at Winston-Salem, N. C., in nodulizing iron ore. An installation that has just been completed for the reduction of nickel and monel metal is giving very promising results. A burner feeding 40 lb. of coal per hour has taken the place of an oil burner consuming 90 gal. of oil per hour, equivalent to 952 lb. of the coal in calorific power giving a saving of almost one-third in heat required, and of still more in cost, since the coal is cheaper than the oil, for this same heating power.

**Electric Steel in England.**—According to a consular report, the first English plant devoted exclusively to the manufacture of electric steel is being erected by the Stobie Steel Co., of Sheffield, on the banks of the Tyne at Dunston near Newcastle. Two furnaces, of 15 and 5-tons capacity, respectively, will be used for melting and refining, and a smaller furnace will be built for producing ferro-alloys. Suitable laboratories will be provided for testing and micrographic purposes. The plant is to be in operation this month.

**Electric Tin Smelting.**—In its issue of January 17, 1914, a prominent American mining paper publishes an article on "Electric Tin Smelting," stating that it is "reproduced from an abstract in the *Mining Journal* from *La Revista Minera y Metalurgica de Madrid*, 1913, based on the experiments carried out by H. Harden in Cornwall and described in the *Elektrotechnische Zeitschrift*. If we add that Mr. Joh. Harden's article appeared originally in *METALLURGICAL AND CHEMICAL ENGINEERING* in the issue of September, 1911 (Vol. IX, page 453), the record of the travelings of this article through different countries and different languages until its return to New York, some two years later, is complete.

**The discovery of platinum in Germany** is reported by Consul Thomas H. Norton, of Chemnitz. The discovery was made at Wenden, Westphalia, in a district where base metal mines are abundant. Analyses of many borings show the presence of platinum in amounts varying from 0.9 to 1.9 troy ounces per cubic yard of rock. An area of 500 acres has been examined by drilling and found to contain platinum-bearing rock.



## The Present Status of the Wood Turpentine Industry\*

BY E. H. FRENCH AND JAMES R. WITHROW

In treating a subject that has as many phases as this one, it will be necessary to discuss briefly an allied industry, namely, that of gum turpentine as distinguished from wood turpentine, in order that the reasons calling for the development of this latter industry may be seen with the proper perspective.

That the wood turpentine industry is at present at an extremely low ebb is unquestionably true. Nevertheless, it is likewise true that its scientific development is an economic necessity for certain localities, in order that waste may be conserved, that the products from waste replace those from the fast disappearing pine and fir forests and that cut over land may be cleared at a profit instead of at a loss. Therefore, in this instance, as is often the case, necessity compels development.

The fact that thousands of dollars have been expended and lost in the incubation of this industry has been due, in our opinion, to three main causes, any one of which in itself would account for failure; first, the lack of practical scientific engineers experienced in this or analogous fields, second financing for the sale of stock and securities rather than product, and third lack of efficient marketing organization. It must also be borne in mind that, owing to the number of different processes, there was caused a lack of uniformity of product, which naturally tended to increase selling costs. Except to the U. S. Navy little, if any, wood turpentine has been sold on thorough specifications. There has as yet been no real attempt by manufacturers to effect a general standard, although a few years ago the producers of the practically defunct steam process turpentine attempted to standardize their product.

One of the important influences that tended at first toward the development of the industry and later proved extremely detrimental was the speculative nature of the naval stores market. This was made up entirely of gum turpentine and rosin, upon the prices of which the relative wood turpentine values were determined. This market in the past has been subject to violent price changes, a fluctuation of from 30 cents to over \$1 per gallon having been experienced, and this was due almost wholly to speculation. Naturally, therefore, during the upward swing of prices an unnatural development occurred, and plants using costly processes and with inefficient management were profitably operated and exploited. It followed, of course, that when the national government, through criminal prosecution, put a stop to excessive speculation, a corresponding reaction occurred, ruining many concerns which required abnormal prices for financial success.

Unreasonably high prices not only encouraged the development of the wood turpentine industry, but also caused an expansion in operations by the gum turpentine manufacturers, so that a larger percentage of trees were boxed, causing overproduction.

### Gum Turpentine

The method of producing oil of turpentine from the resins of coniferous trees consists in cutting a broad, wedge-shaped notch or cup at the base of the tree and removing the bark immediately above the notch for about 18 to 24 inches. The resin exuding from the peeled area runs into the cup at the bottom and is collected from time to time. Each succeeding season the barked area is increased until it reaches about the height of one's head, usually taking five or six years. As many as four "boxes" are thus cut on one tree, de-

pending on its size, permitting only enough of the original bark to remain to prevent the death of the tree.

After collecting sufficient quantity of the resin, it is distilled in a copper still, usually a "fire still," equipped with live steam jet or a water supply. The turpentine thus produced is not carried farther in any refining process, but is ready for the market. The residue in the still is the rosin of commerce and is barreled at the still. The dross obtained by filtering sticks, dirt, etc., from the rosin is in many places being worked into the cheaper grades of rosin. With rosin at an average price, it is generally figured that to make the operation profitable, about 42 cents per gallon must be obtained for the turpentine.

The marketing of the products is done through "factors," as they are called—that is, companies or individuals who contract with the producers for their output, supply them with funds for payrolls, etc., and advances when necessary. These "factors" take the product when produced, but usually have no other connection with the producer. Savannah, Georgia, is the leading naval stores center in the world, and usually Savannah prices are accepted as the standard. Jacksonville and Pensacola, Florida; Brunswick, Georgia, and New Orleans, Louisiana, are also large "factor" centers for this industry.

This method of producing turpentine is generally conceded to give the best turpentine and rosin, but, unless more scientific methods are very widely adopted, the time is fast coming when it will be necessary to supply these products from another source, for present methods of operation are coming to be looked upon as directly antagonistic to all ideas of conservation under American lumbering conditions, as they so weaken the trees that the loss from windfalls is extremely large. In fact, many large lumber companies have given up boxing for this reason, and also because they feel that the growth of the young tree is retarded.

Modifications of the old "boxing" methods are being used in some places. Metal cups are substituted for the box cut in the base of the tree, and it is claimed that the loss from windfalls is considerably reduced by some of these modern improvements. At least one large Southern lumber company is at present experimenting on 5000-acre units in order to determine definitely, if possible, the merits of these new cups and other modifications as to yield and influence on windfalls, and also to decide the effect "boxing" may have on finished lumber.

### Wood Turpentine

Wood turpentine came into commercial notice about the year 1900. The name was, and is, applied to the product obtained from dead and down timber, a waste product called "lightwood." The live or green wood is not so suitable for this manufacture, owing to the moisture content and also to the fact that the bark still remains. Stumps, however, are very valuable, as they contain a much larger proportion of resins than "lightwood." Nevertheless, the cost per cord of stump wood is considerably more, as the stumps usually require the additional expense of removal by explosives. The cost per cord of "lightwood" at the works will run from \$2.00 to \$3.00, making, however, no allowance for its value as waste, while stump wood will vary from \$3.50 to \$5.00 per cord, the price depending on acre stumpage and hauling distances. The manufacture may be divided into five general processes—steam process, solvent process, alkali process, bath process and distillation process.

Before entering into a description of these various methods, we desire to emphasize the statement that the manufacture of wood turpentine necessarily will be-

\*A paper read before the American Institute of Chemical Engineers.

come of far-reaching importance in the future. This is for the reasons that it is utilizing an absolutely waste product and is at the same time clearing cut-over lands and rendering them fit for occupancy.

We wish also to emphasize the statement already made that many past failures were due to the unreasonable speculative condition of the markets. Abnormally high prices of naval stores induced promoters and unscrupulous persons to capitalize their concerns on the earning capacity during this period, thereby making them "stock jobbing" propositions rather than legitimate manufacturing institutions. This kind of financing, while apparently expanding the industry, really retarded development, as the energies of the management were expended primarily at the office end at the expense of the manufacturing organization.

We have seen from time to time figures of promoters regarding yields and manufacturing costs of the different processes which are not in accord with the results obtained from continuous operation. It may not be entirely without value, therefore, to cite some comparative yields and operation costs in the different processes. This is especially true, since there does not appear to be any published data of this nature.

While the records themselves of individual plants would be interesting, such records are often misleading, and in view of actual or possible competition the location of plants themselves must be withheld. In submitting data as to yields, values and productive costs we have compiled them mainly from the actual results obtained during continued operation of a number of large plants. As so many elements making up these figures are variable, owing to location, construction and raw material, our endeavor has been to average them so that a comprehensive idea may be had as to actual results obtained commercially.

**Steam Process.**—This process was the first to be extensively placed in commercial operation and is very simple in its construction and handling, consisting merely of hogging the wood and placing it in a steel cylinder, usually holding about a cord, distillation being carried on with live steam and under varying pressure. However, there was probably little difference in results whether a maximum of five pounds or twenty pounds pressure was used. Distillation was carried forward until oils ceased to be obtained in quantity.

It should be borne in mind that there is a decided variance in the resinous content of wood, therefore, it was quite possible to make a selection that would run as high as 30 gal. of turpentine to the cord. We believe the following figures, however, based on a cord of long leaf yellow pine lightwood, weighing 3500 pounds, would be the average:

Turpentine, 9½ gals. at 35 cents.....	\$3.32
Pine oil, 3 gals. at 35 cents.....	1.05
Total value of products.....	\$4.37

#### Production cost per cord:

Production Cost per Cord.	
Wood .....	\$3.00
Labor .....	1.00
Barrels .....	0.42
Freight (approximate) .....	0.20
Selling commission .....	0.25
	\$4.87

The fuel cost is only the labor of handling the treated chips. However, there is no allowance made for the office, upkeep, depreciation insurance, etc. Therefore, it can be seen that the steam process necessarily, in order to be profitable, demands a market price considerably in advance of the present markets.

The price of wood turpentine is always a few cents per gallon under that of gum turpentine. The quality of the product produced by the steam process, however, is excellent. Our opinion is, nevertheless, that at least

50 cents per gallon is necessary as a minimum for successful operation.

**Solvent Process.**—In the early development of this process the wood was subjected to the old steam treatment and subsequently treated with carbon-disulphide for the recovery of rosin. The loss of solvent rendered it impractical. In the next stage of development the wood was hogged and placed in digesters for the recovery of turpentine and pine oil. Then the solvent (a low grade of gasoline) was added, live steam was applied, recovering some turpentine, pine oil and solvent by distillation, and the dissolved rosin drawn off, its volatile matter being recovered by distillation.

This has been improved, subsequently, in some instances by omitting preliminary steaming, adding solvent direct and recovering this with the turpentine and pine oil by live steam in the primary distillation, obtaining rosin alone when the still is drawn. The rosin, however, is soft, and difficulty has been experienced in obtaining a hard product, but this is overcome by subsequent treatment. In either method, a considerable loss of solvent is always entailed, varying from 17 to 30 gal. per cord.

The approximate yields and operating costs per cord are as follows:

Turpentine, 9½ gals. at 35 cents.....	\$3.32
Rosin, 400 lbs., at \$4.00 per 280 lbs.....	5.72
Pine oil, 3 gals. at 35 cents.....	1.05
Total value of products.....	\$10.09
Production Costs per Cord.	
Wood .....	\$3.00
Labor .....	2.50
Loss in solvent at 15 cents (17 gals.).....	2.55
Barrels .....	0.42
Rosin barrels .....	0.25
Selling costs .....	0.50
Freight .....	0.75
Total .....	\$9.97

Again the actual fuel cost in this process is negligible as use is made of the "treated chips." No allowance is made here for insurance, upkeep, overhead and interest charges, refining costs or depreciation; therefore, it is plainly evident that at present market prices, at least until improvement is made in yields or in minimizing costs, there is not sufficient margin for successful operation.

However, it is quite possible that by using the "treated chips" for paper pulp manufacture that this process will be made of commercial value. The operation in this case would have to be maintained on an enormous scale in order to supply treated chips for a pulp plant unit of an economic size. A plant using this solvent system and built on a very elaborate scale was in operation in Southeastern Georgia, and, despite the most advantageous financial backing, was unable to operate profitably on a weakened market, and is now in the hands of receivers.

This citation alone probably would not necessarily condemn the process, but as several smaller plants are either in like position or shut down, it indicates the necessity of research or development if ultimate success is to be attained. As with the steam process, many claims of higher yields than we have above credited are made by interested parties, but these claims are still subject to substantiation.

**Alkali Process.**—This process is essentially one to be applied to the alkali processes for manufacturing paper pulp from resinous woods with the recovery of turpentine and rosin and at the same time improving the quality of the pulp and promoting ease of manufacture. The process is well covered by patents.

The basis upon which this method rests is the fact that the sodium hydroxide saponifies the resins in the wood and the sodium resinate thus formed may be separated from the spent soda pulp liquor by temperature regulation. The wood is handled in the same manner



as in soda pulp manufacture, except that after digestion the spent liquor is cooled for the separation of sodium resinate before this liquor proceeds to the evaporators. This product has been so purified and refined commercially, as to produce a good quality of paper size. The resinate may if desired be manufactured into rosin by acid treatment, or destructively distilled, obtaining rosin oils. The turpentine is recovered from the digester blow-off during the digestion operation.

This process is apparently theoretically sound, but requires the outlay of capital to develop thoroughly the mechanical details. Fifty to seventy thousand dollars were expended in one case to demonstrate its commercial possibilities, and some results were obtained. However, the enterprise has not been financially successful and the plant has been dismantled, a fact which may be due to faulty engineering or other causes, and even though the process appears enticing from a theoretical viewpoint the fact remains that the trial was not successful, and there is no process of this kind in actual operation.

Nevertheless, it is our opinion that eventually it will be of commercial importance, and ultimately the combination of the two industries, paper pulp and turpentine-rosin recovery, thus utilizing resinous wood, will be successful. Unusual yields of turpentine are claimed by a Florida plant using an alkali bath, but satisfactory arrangements have not yet been made regarding rosin recovery.

**Bath Process.**—This process must not be confounded with the recently suggested process using a bath or envelope of oil external to the oven for the purpose of heating the same. This external bath process has not been long enough in operation to demonstrate its future, and it will be interesting to note if certain fundamental operation difficulties can be overcome.

By bath process we refer to the process commercially called the bath process which has been in operation for some time, and in which the bath is within the oven, or retort, in contact with the wood itself. Three plants using this method have been built, the first in North Carolina, which has been dismantled; the others at Mt. Pleasant, Ga., and Jacksonville, Fla., which have not been successful under low market conditions, and both of which have gone into receivers' hands within the last few months.

The process itself was divided into two separate general operations. First, the recovery of turpentine and pine oil, or, as styled, "sweet spirits," and subsequently the destructive distillation of the wood itself, although this second operation was not contemplated in the original process.

The operation has a decided advantage over the solvent and steam processes in that it does not require the "hogging" of the wood.

The general construction used in this first operation consists of steel cylinders at Mt. Pleasant, and concrete ovens at the Jacksonville plant, each holding five to nine, 1 to 2-cord steel cars, similar in construction to those in common use in hardwood distillation; thus each oven holds about nine cords of wood. Placed at the side of the oven is a heater equipped with a large cast iron worm connected to the bottom of the oven. To the rear of the heater is placed a large steel or concrete reservoir connected by cast iron pipe to the top of the oven and also to rotary pumps, which in turn are connected to the heater pipes.

The loaded cars are placed in the oven and melted rosin or pitch is run into the reservoir and circulated by the pumps through the heater and the bottom oven connected. This pitch, after filling the oven, overflows into the reservoir and is thus continually circulated through the heater and oven, thereby vaporizing the

volatile resinous bodies and without dissociating the wood fibre. The turpentine and oil vapors are carried through a "vapor" chamber where the high boiling liquids that are mechanically carried by the vapor are separated, the vapor continuing to an ordinary tubular condenser, where the crude "sweet spirits" are obtained. Afterward the "sweet spirits" are refined, the products being turpentine, pine oil and a tarry residue. The time required to "treat" a charge varies in the plants mentioned from seven to ten hours, and the product obtained is of high quality, though not so good as steam process turpentine.

At first sight it would appear that in this process the rosin from the wood treated would gradually increase the volume of the bath and rosin be thus manufactured. The reverse of this, however, is the case, as a very serious loss of bath is actually realized. This is, in fact, a serious drawback to the process, and is probably due to the formation of volatile rosin oils when the liquid bath encounters the high temperature of the heater. These rosin oils are volatilized and pass into the "crude spirits" and are lost in the refining residue, as only from 65 to 70 per cent of the spirit is received as turpentine and pine oil. By proper arrangement this difficulty could have been avoided.

This process is also seriously handicapped by the fuel consumption of the heaters and the heavy upkeep for heater pipes and pumps. Nevertheless, with proper design, operation costs would have been much reduced from that actually experienced.

After refining, the results from this "sweet process" could be averaged as follows:

Turpentine, 7½ gals. at 35 cents.....	\$2.62
Pine oil, 2½ gals. at 35 cents.....	0.87
	<hr/> \$3.49

After the charge is withdrawn in this first operation the "treated" wood is placed in ovens similar to those used in the hard wood industry and there subjected to destructive distillation. The results obtained here are very important, as a good market has been created for these products. An average of from 68 to 70 gal. of oils is obtained, together with a like volume of "acid water," the latter a "waste," although its utilization was accomplished just prior to the receivership of one of the mentioned companies. In addition there remain in the cars approximately 900 lb. of charcoal, and there is produced about 10,000 ft. of non-condensable gas per cord which is of fuel value.

This crude distillate above mentioned is called "destructive distillate" or "D. D. product" to distinguish it from the product derived from the resins called "sweet spirits." On refining there are obtained the following products per cord:

Tar, 41 gals. at 8 cents.....	\$3.28
Light oil, 6.8 gals. at 12 cents.....	0.81
Heavy oil, 10 gals. at 12 cents.....	1.20
Charcoal, 36 bushels at 7½ cents.....	2.70
From "Sweet Process".....	3.49

Total value of products.....\$11.48

Costs of Production per Cord.	
Wood .....	\$3.00
Fuel .....	3.25
Labor .....	2.75
Cooperage .....	1.00
Selling costs .....	0.60
Freights (approximate) .....	0.75

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\$11.35

Again it can be seen that this process handled as it has been in the past cannot be operated successfully on a low market, as no allowances have been made for upkeep, insurance, interest charges, refining costs, management or depreciation. Although the loss in bath is partially made up by the pitch obtained, it can be seen from these costs that improvement must be had before this process can exist during low market conditions. It is not to be inferred, however, that the prin-

ciples upon which the process is based are entirely faulty. The reasons for its failure appeared to be lack of knowledge as to the chemical nature of the products and troubles consequent to improper construction and operation.

As is common with approaching dissolution, strenuous efforts at improvement were made in this process, and, despite well known prior failures, experiments were completed and operation commenced for the utilization of the waste "acid water" just before the closing of one of the plants. The results proved interesting and promised excellent recovery, as the products recovered, including acetate of lime and wood alcohol, represented a net gain of well over \$1.50 per cord.

*Distillation Process.*—As the wood turpentine industry now stands, the destructive distillation process apparently has the best chance of commercial success, as it is not only more simple in construction and operation, but yields more in volume of products. Chemical and engineering skill, nevertheless, are necessary for this success.

The distillation process may be subdivided into three divisions. First, that division analogous to hard wood distillation. This method in its primary operation is very similar in equipment and design to the usual hard wood distillation plant, the wood being placed in steel cars and run into ovens. The products derived from the resins and those from the dissociated wood are collected together, and separation is made during refining, although some attempt has been made at fractional distillation in this primary stage. This method gives a much inferior grade of turpentine, etc., owing to the commercial difficulty of eliminating the pyroligneous bodies, and the product will not answer to the permanganate test, which indicates pyroligneous matter. The tar produced in this operation is usually resinous and for some uses therefore objectionable.

The second division is merely a modification of this process, the ovens being in duplicate, and distillation for the resinous bodies being carried out in one oven, so designed or "set" that the temperature can be maintained approximately uniform. After the resinous bodies have been obtained the "treated wood" is withdrawn and placed in a second oven, and in this oven the distillation is carried at a higher temperature for the destructive distillation of the wood itself.

The third division is that using concrete ovens containing 12-inch heater pipes, running the length of the ovens. These ovens have Dutch-oven connections and the flue gases travel through these pipes, and it is claimed that temperature regulation is more easily accomplished.

In all these processes the products obtained are the same, except so far as the degree of purity is concerned.

The first distillate, or that from the resins in these methods will run on an average 22 to 24 gal. of "sweet spirits." This on refining will give from 50 to 60 per cent, or from 12 to 14 gal. of marketable turpentine, and from 9 to 10 per cent of pine oil, or from 2 to 2½ gal., and also 100 lb. of a very resinous pitch.

The destructive products are the same as those from the "bath process." Thus it can be seen that the gross total in this operation should be materially higher than in the other processes, while the operating expense is very much lower. This, including wood, upkeep and in fact all expense, should not, under proper design, construction and management run over \$9.00 to the cord.

The particular objection raised against the destructive distillation process is that the products are difficult to market, and this has been true to a certain extent in the past, but when it is considered that many of these

bodies were new to the trade, this condition cannot be wondered at, and at present the marketing is not more difficult than products of other processes. In fact, just now there is an unusual demand for these products.

### Markets

It may perhaps be of interest to call attention to the various developed markets for the D. D. products, for we all realize that the marketing of products is at least equal in importance to the manufacture; and this industry shows many instances where comparative merit of process and operation was wholly lost by inferior marketing facilities, and, on the other, hand, instances in which unsound operation was maintained for considerable time by a remarkably efficient selling organization. The latter cases, while losing ventures to those financially interested, have no doubt succeeded in creating a growing demand for the products as indicated by the prices obtained now for them with many plants closed down.

At the time this article is written tar could easily be sold for 12 cents per gallon, as compared to the 8 cents allowed in the cost data in the article, but which should be considered maximum, as the future, undoubtedly, will increase supplies so as to bring these prices back to a more nearly normal condition.

This fact, however, does show that a demand has been created that did not exist prior to the quite recent establishment of plants of this nature. Perhaps this condition is more clearly evidenced in the heavy D. D. oil, for which 22 cents per gallon is being obtained. The tar demand had in a measure been previously supplied by that known as "kiln tar," made at works using the kiln system for charcoal manufacture from resinous woods.

The product mentioned as D. D. light oil is at present most difficult to market profitably—this is on the market in this form and is used to some extent by manufacturers of disinfectants. However, it has been fractionally distilled and has been used locally as a substitute for gasoline for use in engines and has proven itself to be more efficient than gasoline. The comparatively small amount of this product makes its use in this manner merely of local interest, but it indicates a real value of the product.

The Heavy D. D. Oil has been in consistent and increasing demand, particularly in the paint industry and notably for shingle stains, and also for the manufacture of tar oils, for which there is a large foreign demand. The necessity of an energetic market agency was in one case well illustrated within the past year with this product. One large concern was offering this product for 5 cents per gallon, finding it impossible to market, having nearly 100,000 gal. in storage, while at the same time another company was unable to supply its customers at 18 cents per gallon. Of course, the latter considered the purchase from the former, but feared future competition, in case, as seemed dangerously probable, the former concern should learn of their customers.

The pitch produced in the distillation process and distinguished from the tar has a firm market demand from ship chandlers and also is sold for uses, such as coating silos, rendering them impervious to moisture.

The tar, of course, has its established uses, with rope manufacturers as well as with paint producers, while the charcoal consumption, particularly in the south, is very steady both for domestic use and manufacturing. Of the number of suggested specialties based on the use of tars and oils, doubtless a few will ultimately contribute a steady demand for a portion of these products.



### Cost of Installation

The various processes have in most instances exceeded reasonable installation costs. Undoubtedly the same is true in any newly established industry, and more particularly in cases where, as pointed out in this one, prices could be obtained that were out of all proportion to production costs.

Entire equipment of a steam process plant should come well within \$750.00 per cord capacity, while the solvent process complete should be approximately \$2,000.00 per cord; this also should be approximately that of the bath system, while the destructive distillation method ought to be very close to \$1,500. In making these general estimates neither working capital nor purchase of timber or stumpage is considered.

### Conclusion

When your attention is brought to the fact that the destructive distillation plants alone have been able to survive recent price depression, it is reasonable to conclude that, in the present state of the art, this method has inherent advantages. Nevertheless, in this type of process, there is room for much improvement, particularly in refining and the utilization of waste products ignored in the past. Constructive chemical engineering apparently has, in this industry, opportunity to create an unusually profitable business, provided it utilizes the unfortunate mistakes of the past by combining parts of the various processes.

It is not to be inferred from this article that recommendations are made for the encouragement of any particular process, the motive is merely to outline present conditions, or, broadly, to show cause and effect, and also to show, if possible, that many elements are as necessary in this industry as in any other to attain success. Statements have been made to the effect that failures in most instances were due to lack of real engineering skill, and this is partly true, but lack of skill is not wholly accountable for even the engineering failures, for no amount of theoretical engineering skill can replace the knowledge acquired from continued intimate contact with the going operation.

Neither does this statement take into consideration the marketing organization, which is also an essential and is always confronted with the general economic situation, which does not affect directly the operation.

It can be seen from this outline of the industry that its very existence was primarily due to an unnatural market condition, and as the field for profit and exploitation was so enormous it can hardly be wondered at that unusual activity was had in its promotion.

Butte and Superior made a new record in milling efficiency in November, 1913, when the concentrates averaged 50.58% zinc and the recovery over 90%. The total production for the month was 10,995 tons of concentrates containing 11,123,000 pounds of zinc.

Plans and some details of the new Massachusetts Institute of Technology are announced in the November, 1913, issue of the *Technology Review*: "From the waterside it will present the appearance of a great white city of majestic proportions, with the long vistas of its facades broken by suitable intervals, and relieved by the foliage of shrubbery and trees. The interest of the spectator will center in the broad court extending back a sixth of a mile from the river and leading by terraces to the great colonnaded portico of the central building of the group." The educational portion will be a connected group of buildings three and four stories in height. The arrangement will be flexible to provide for future expansion of the departments.

## Mechanical Refrigeration—I

### Choice of Refrigerants

BY H. J. MACINTIRE

Mechanical refrigeration is a process of cooling by means of a reversed steam-engine cycle. In this cycle external work is done on some agent either by heating a solution directly with steam or by some other means or by compressing the vapor with a metallic or fluid piston. Heat is added to the working fluid at a lower temperature, and is abstracted at the higher temperature—mechanical energy having been supplied between these two processes of sufficient amount to make it possible. In mechanical refrigeration, then, a refrigerant—the special term used in referring to the working agent in this particular thermo-dynamic cycle—has to be employed.

There are certain essentials in mechanical cooling, as far as the working medium is concerned, which usually must be complied with. For instance, the volume of the refrigerant must be reasonably small, otherwise the refrigerating machines become bulky and expensive. The kind of refrigerant chosen must be such as will give readily the desired temperature; it must be cheap, if a new supply is used at the end of each cycle, or it must be of stable composition, if the refrigerant is used continually. With these factors in mind, an analysis of the possible refrigerants will now be made, and the advantages of the more common ones will be considered.

One of the first of the practical refrigerants to be used was *air*. It is without cost, is available everywhere and is harmless if allowed to exhaust or leak out of the system. Yet it is now found in but a few installations and mostly in a modified form called the "dense air machine." The reason for the abandoning of air is because of its low heat capacity, as will be clearly seen on a consideration of a typical example. A pound of air at  $-100$  deg. Fahr. might be allowed to come into metal contact with brine or other substance whose temperature it is desired to lower.

If the air is allowed to be raised to  $+30$  deg. Fahr., or a total heating of the air by 130 deg. Fahr., the possible amount of refrigeration would be, per pound,  $130 \times 0.24 = 31.2$  B.t.u., and the volume of this pound of air at atmospheric pressure would be approximately 12.4 cu. ft.

Should a closed cycle be employed (the air being used over and over) the volume of 1 lb. of the air leaving the cooling coils may be one-quarter or one-fifth of the amount above, depending on the cooling pressure used. In the last case refrigeration is obtained by the so-called "dense air" cycle. However, even the dense air refrigerating machine is bulky, inefficient, and troublesome to operate and except for unusual circumstances machines using air as a refrigerant are obsolete.

Let us now consider the case of easily condensed gases, i.e., the vapors, and allow the liquid refrigerant to pass into the cooling coils. In order to evaporate this liquid, heat has to be added, and in the evaporation an amount of heat equal to the latent heat of vaporization has to be taken away from the surrounding bodies—the latter thus being cooled by a like amount. The amount of this latent heat, in heat units, depends on the substance and somewhat on the temperature of vaporization, and may be 160 B.t.u. per pound for ether, 360 B.t.u. for alcohol, 550 B.t.u. for ammonia, and 1000 B.t.u. for water vapor. Even in the case of ether the amount of possible cooling per pound of refrigerant is above five times that possible in the case of air, whereas it is only one-sixth of that theoretically possible when using water vapor.

From what has been said it is clear that a very wide range of substances suitable for refrigerants are at hand, and yet the number actually used is small—less than a half dozen, namely, water vapor, sulphur dioxide, carbon dioxide, and ammonia. The method of elimination, and the choice of a possible refrigerant, is suggested by what follows under the topics of cost, chemical and physical properties.

### Cost

The cost of the four refrigerants chosen for our analysis—water vapor, sulphur dioxide, carbon di-

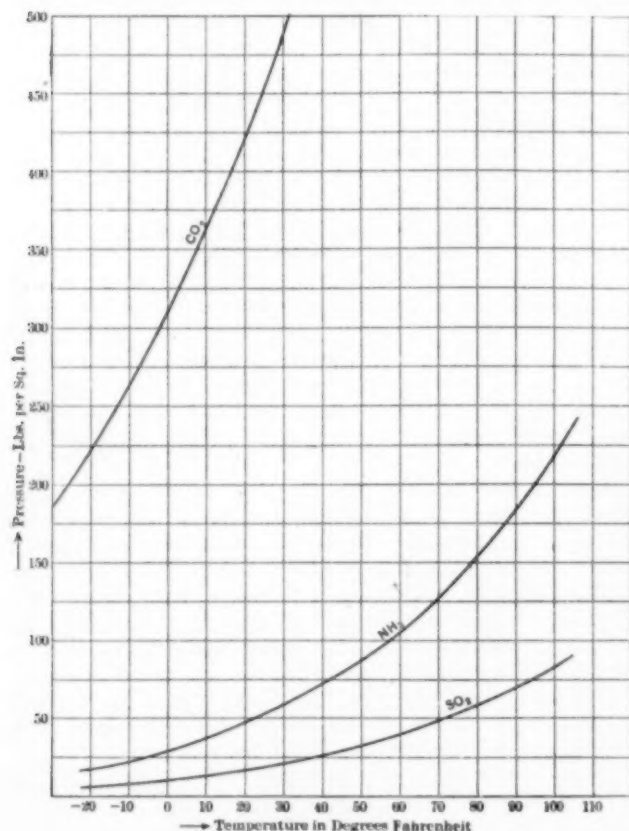


FIG. 1—PRESSURE-TEMPERATURE CURVES FOR DIFFERENT REFRIGERANTS

oxide, and ammonia—is, except for the first one, much too great to allow them to be used in any way except continuously. Therefore, a closed cycle is necessary, and when the working medium has performed its function of cooling it is compressed again, and made to re-

### Chemical Properties

The chemical properties of the refrigerant are important as far as concerns the corroding action on metal, safety, and ability to withstand disintegration. Anhydrous sulphur dioxide has been found to attack iron at about 205 deg. Fahr., but this is a temperature which is never reached under normal operation of the compressor. Ammonia corrodes copper and copper alloys, so that this metal has to be entirely eliminated from the ammonia circuit. As far as their action on animal life is concerned (water vapor excepted) the refrigerants under consideration are almost equally dangerous. Sulphur dioxide and ammonia are easily detected by their smell, but carbon dioxide (when pure) is odorless and as much as 1 per cent or two per cent may be present in the air without discomfort. Ammonia has been found to burn at 900 deg. Fahr., and is also perhaps the least stable of the four compounds, hence successive use in the refrigerating system tends toward a slow disintegration.

### Physical Properties

So far this analysis of the refrigerants (except for the cheapness and safety of water vapor) gives no reason for particular preference of any one over another and it remains for a critical consideration of the physical properties to determine what refrigerants are of value in given cases and which are the most desirable under those particular conditions. The physical properties may be compared by considering tables of these vapors in the condition of saturation. Table I and Fig. 1 assemble this data for the several refrigerating media which we are examining.

Referring to Table I: Column 1 gives the latent heat of vaporization for the four refrigerants, assuming a uniform boiling temperature of these of  $-4$  deg. Fahr., this temperature being maintained constant by keeping the pressure in the cooling coils uniform and equal to the amount given in column 10. Columns 2 and 3 contain the values for the heat of the liquid at 68 deg. Fahr. and  $-4$  deg. Fahr. In this regard it is assumed that the cooling water available is of such a temperature that the refrigerant may be cooled to 68 deg. Fahr. The corresponding condenser pressure is given in column 9 as well as in the figure.

Column 4, obtained by subtracting the sum of 2 and 3 from 1, gives the net theoretical amount of refrigeration in B.t.u. per pound of the refrigerant at the operating conditions. It should be clear that the temperature of the liquid refrigerant as it leaves the condenser has a decided influence on the values in 4, as the liquid has to be cooled to the temperature at which refrigeration takes place (here  $-4$  deg. Fahr.) before

TABLE I—LIQUID REFRIGERANT AT EXPANSION VALVE  $= 68^{\circ}$  F.

	1	2	3	4	5	6	7	8	9	10
	Latent Heat at $-4^{\circ}$ F. ( $L_1$ )	Heat of the Liquid at $68^{\circ}$ F. ( $q$ )	Heat of the Liquid at $-4^{\circ}$ F. ( $q_1$ )	Refrigeration Theoretically Possible [ $L_1 + q_1 - q$ ]	Ratio of Columns, 4/1	Specific Volume at $-4^{\circ}$ F.	Volume in Cubic Feet at $-4^{\circ}$ F. for 100,000 B.t.u. of Refrigeration.	Column 7, with $\text{CO}_2$ Expressed as Unity.	Approximate Condenser Pressure.	Boiling Pressure, Corresponding to $-4^{\circ}$ F.
Sulphur Dioxide, $\text{SO}_2$ .....	172.66	11.92	— 11.07	149.67	86.7	8.22	5,490	13.42	48	9.25
Carbon Dioxide, $\text{CO}_2$ .....	118.87	22.42	— 17.87	79.58	66.9	0.313	409	1.00	220	2.89
Ammonia, $\text{NH}_3$ .....	575.3	29.9	— 27.9	497.5	86.5	10.08	2,025	4.95	130	27.13
Water Vapor, $\text{H}_2\text{O}$ .....	1,094.4	66.1	— 56	1022.3	93.5	16,750	1,635,000	4,010	0.339	0.017

peat the operation. Water, then, as it is practically without cost, has a great advantage over the other three and, other things being equal, it would be the most acceptable substance for a working medium. Unfortunately the cost is not the only consideration.

any useful refrigerating work may result. This cooling is done at the partial evaporation of the refrigerant, and the net result is a decreased value for the possible refrigeration per pound of the medium. The desirability of using cool condensing water in the con-



denser is apparent, although carbon dioxide only seems to be affected seriously by this, as shown in column 5, which gives a percentage ratio of columns 4 and 1.

As a closed cycle has to be used, the vapor in the refrigerating coils has to be compressed and returned to the condenser in order to obtain a liquid again. The usual method of so doing is to pass this vapor into a compressor, similar in design to an air compressor. The capacity of the refrigerating plant will depend on the piston displacement of the compressor and the volume of 1 lb. (the specific volume) of the refrigerant, the ratio of the two being the number of pounds of the refrigerant compressed and condensed per unit time. Column 7 gives the theoretical displacement in cubic feet of such a compressor for 100,000 B.t.u. of refrigeration and column 8 repeats simply the last figures but with carbon dioxide expressed as unity. Assuming the same rotary speed, the compressor using sulphur dioxide would have to be 13.42 times the size required for carbon dioxide and with ammonia 4.95 times, whereas the value for water vapor is absurdly large.

Referring to columns 8 and 9 it is seen that water vapor is out of the question when used in a reciprocating compressor because of the great volume of the vapor accompanied by the extremely low pressure. Sulphur dioxide has a conveniently low condenser pressure even with condenser water of 100 deg. Fahr. or more, which makes it very useful in the tropics, especially as its efficiency does not decrease greatly—a fact which may be made clear by working out column 5 for this temperature. Its slight pressures allow light construction and enable the machine to be made portable if desired. The size of the machine has to be considerably greater than for ammonia or carbon dioxide. The latter requires a much smaller compressor, but the working pressures are excessive. The cylinder and piping frequently have a working pressure of 900 lb. to 1000 lb. or more; and the leakage loss becomes large as a rule. Low refrigerating temperatures, however, are easily obtained.

In America from 85 per cent to 90 per cent of the total mechanical refrigeration is done by using ammonia as the refrigerant. The reasons for this are to be found in the moderate pressures encountered, its efficiency with condensing water of from 70 deg. Fahr. to 100 deg. Fahr., its medium piston displacement, as shown in column 8, and the ease with which the more usual refrigerating temperatures may be reached. Some space, as far as the compressor is concerned, could be saved by using the carbon dioxide compressor and for this reason as well as because slight leaks are not so noxious or harmful it is commonly found in marine and hotel use. For most industrial work, however, for the reasons given, ammonia as the refrigerant is much to be preferred.

University of Washington, Seattle, Wash.

The Third International Congress of Tropical Agriculture will be held at the Imperial Institute, South Kensington, London, S. W., from June 23 to 30, 1914. The following subjects, among others, will be discussed: technical education and research in tropical agriculture, labor organization and supply in tropical countries, scientific problems of rubber production, methods of developing cotton cultivation in new countries, problems of fiber production, the cultivation and production of rubber, cotton and fibers, cereals and other foodstuffs; tobacco, tea, cocoanuts, etc. The subscription for membership in the congress will be £1. All correspondence is to be addressed to the Organizing Secretaries, Third International Congress of Tropical Agriculture, Imperial Institute, London S. W. The International Rubber and Cotton Exhibitions will be held simultaneously.

## A New Design of Filter Press\*

BY ALFRED BURGER

Before describing the new filter press, I intend to give a short survey of the developments in the construction of pressure filters for filtering and washing purposes, and to point out certain lines along which improvements have been made.

If we look back a few decades it seems as though the activities in this branch of chemical engineering had come to a temporary stop with the general introduction of the chamber filter press. This machine had so many advantages that it rapidly found its way into practically every chemical factory and is still in general use to-day. It is a strongly built, reliable and practically fool-proof machine and does do the work for which it is built, though in fact badly, especially since we know that better results are obtainable.

For large-scale operations, however, the chamber filter press had its limitation. Filling and washing took a long time and consequently too many machines were required for handling the slush, and the cost for labor ran up very high. For this reason many plants stuck to decantation or table washing, finishing with a squeeze press. Others which were more progressive tried filtering and washing in the press, but had to give it up.

Judging from the numerous attempts subsequently made to find a cheaper and more convenient way of discharging the solid matter, it appears that the separating and putting together again of the many plates and frames after each cycle plus the cost of labor involved were considered the chief disadvantages of the chamber filter press.

In trying to overcome these drawbacks it was soon found that the chamber filter press did not lend itself very well to such improvements. The only way in which the solid matter can be removed without separating the filter members is by sluicing. This method, though it has proved very successful in some cases, is but a compromise between the old way and something better that was yet to come. Besides, sluicing is only feasible if the solid matter is worthless.

Better results in this endeavor were to be expected from another kind of filter, the leaf type, which was then already in use, though in a primitive form and chiefly for clarifying purposes. It seems as though the inventors of this latter type did not have an adequate conception of the filtering problems confronting engineers in certain chemical and metallurgical fields. Nothing was done by them toward making the apparatus more useful, enclosing the leaves in a suitable shell which would permit an easy removal of the cakes.

The proposition of improving it in this direction was taken up some years later out West, and undoubtedly the great opportunity there revealed has been an active stimulus to the inventors of two types of leaf pressure filters perfected in recent years.

These two are giving very satisfactory results indeed, especially that type of which a model has been exhibited at a previous meeting of the Institute. Yet, if we compare the working of such a modern leaf-type filter with an ordinary chamber press, we find that the superiority of the former is due not to the mechanical discharging but to the greater washing efficiency. Thus the time required for separating the plates and frames and closing them up again at the end of each cycle seems, after all, not to be such a disadvantage as had been represented. The discharging feature, as will be demonstrated later, is in fact a secondary matter.

Besides these successful attempts to solve the prob-

\*A paper read at the New York convention of the American Institute of Chemical Engineers.

lem of discharging the solid matter in a more satisfactory way than is possible in a chamber press, other lines of improvements have recently been taken up with the view of constructing a filter press in which the filtration is followed by a squeezing of the cakes mechanically and to effect filtration at a much higher pressure. But in my judgment no great advantage will be derived from this direction. Owing to the constructional difficulties to be surmounted and to complications of such machines their use will be limited, while filtration under much higher pressure is no more effective.

Some years ago the writer became familiar with a process of which the filtration of the slush constitutes one of the most important operations, and as the results obtained in the filter presses employed seemed to indicate ample room for improvements, I subsequently and incidentally gave some attention to filter press matters. It seemed to me that not so much the time and labor involved for separating and putting together again the plates and frames, but rather the low washing efficiency of the chamber press was the feature most deserving of correction.

When occasionally filtering the same material through a filter funnel in the laboratory it surprised me that the liquor ran so nicely through the cake, and in proportion much less water was needed for washing the residue free from soluble matter than the big filter press required working with 50 lb. pressure. This observation led me to apply the same washing principle to a chamber filter press which consists of letting the water penetrate the cake in the same direction as the solution. Fig. 1 illustrates this. The cylindrical parts of the two filter funnels facing each other resemble a section through a chamber in a filter press having an opening at the bottom and top. Two distinct cakes are formed which are washed from inside.

To what reason the bad washing in the ordinary chamber press is due has been described before, but let me add, the reversing of the current is not alone responsible for the bad results obtained. Cakes which I have seen seemed to indicate that the inefficient washing, especially in case of slimy solids, is due to a great extent to the uneven filtering soon after fresh blankets have been put in the press. The cakes that begin to

section through cake

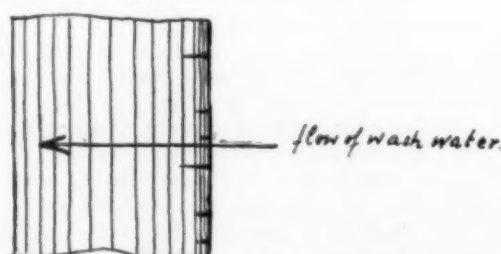


FIG. 2—CRACKING OF CAKES

form on the wash plate sides are, owing to the continuous good condition of these blankets, considerably denser. The very first deposit is often a relatively hard layer which on reversing the current for washing pur-

poses cracks. Cakes occasionally examined always showed this cracking distinctly (Fig. 2) and a separate testing of the different layers revealed plainly how the water had penetrated the cakes. The hard brittle crust in one instance contained about 6 per cent, the soft central part 0.4 per cent and the left layer 1.2 per cent of soluble matter not washed out.

What I have termed a new filter press is the direct-flow principle, as illustrated in Fig. 1, applied to a chamber filter press of very simple construction. The method of operation is still simpler. Fig. 3 shows a cut through the stationary head and first chamber with pipe connections. The liquid-solid enters from the bottom channel with valve *O* open. As soon as the material begins to overflow, *O* is shut. Filtration starts and is continued until sufficient cake has formed to leave but a space in the center of  $\frac{1}{2}$  to  $\frac{1}{4}$  in. Water is then switched on, and after washing has been completed the excess is withdrawn by means of compressed air introduced from the top. Air is then blown through the cakes for a short while when the press is opened and the cakes discharged. Of course, the method just described is not sufficient to insure good results. Certain constructional details are absolutely essential, as otherwise trouble will arise causing complete failure. Now, rather than describing those details I prefer to give a few figures showing the work done by presses in actual operation. Thus I think it will be better appreciated what these improvements amount to.

For filtering and washing an aluminium hydrate pre-

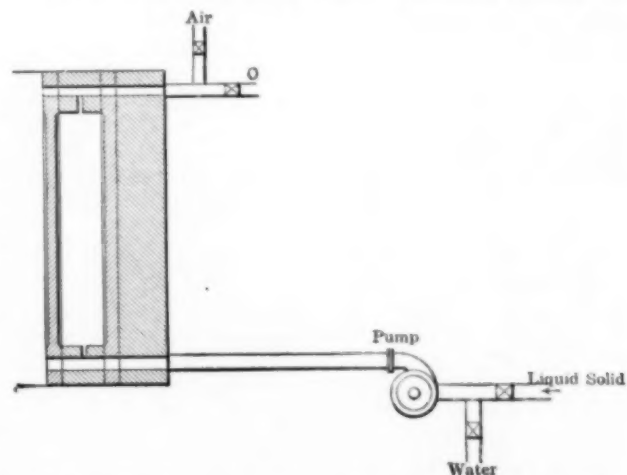


FIG. 3—FILTER PRESS BASED ON DIRECT-FLOW PRINCIPLE

cipitate it used to take six hours in the regular chamber press for washing the cakes free from the solution, while with the press of my design one hour is now required. In case of a prussia-blue, washing was reduced from twelve hours to two. A carbonate of lime residue was washed free from solution in less than one-third the time a Dehne press required, and the amount of water needed for doing it was reduced to one-third.

The excellent results obtained induced me to file application for patent for this device. In looking over patent specifications as to improvements on chamber presses I was somewhat surprised to find that apparently nobody before fully realized the great advantages to be gained by this very simple mode of filtering and its general application. I want to emphasize that good results are only obtainable if filtering and washing is carried on without interruption and with steadily increasing pressure. Introduction of air or steam between filtering and washing, for instance, is impossible. Also a clearance must be left between the cakes of at least  $\frac{1}{4}$  in. to facilitate an easy and even distribution of the washing fluid.



Besides these very great advantages over the ordinary chamber press in respect to time and efficiency of washing, there are a number of others as, for instance, lower operating pressure, absolutely clear filtrate, less leakage and less pressure required for keeping joints tight, which means a saving in blankets.

A plate and frame filter doing such efficient work compares very favorably with a leaf-type filter equipped with the best mechanical devices for discharging the cakes. I am able to prove this with the aid of figures obtained from presses working on the same material and under identical conditions.

	Washing efficiency	Final moisture content	Lbs. of dry solids per sq. ft. filter area per hour
I, chamber press.....	20%	30%	6.8
II, improved chamber press	60%	28%	3.
III, leaf-type press.....	54%	36%	3.5

As to the calculation of the washing efficiency of a filter press as given in the table I shall explain this more fully later on.

A glance at the collated figures reveals clearly the inferior work done by the old chamber press. Its washing efficiency is only one-third of that of the two other presses, and consequently the output for unit filter area which is chiefly influenced by the washing efficiency is still less, about one-quarter. It is evident that this press drops out of consideration for processes in which large amounts of material have to be filtered and where wash-water means evaporation.

A comparison of the presses II and III proves that my previous statement as to the capacity per unit filter area being principally determined by the washing efficiency is correct. The difference in the quantity of cake handled per square foot per hour in this particular case was only 0.5 lb., or 14 per cent. This is small, indeed, and will only have an influence in favor of the leaf-type press when huge quantities of material are to be put through, but then it is rather the saving in labor which will enter into consideration. On the other hand the lower moisture content of the cakes obtained in the improved chamber press is decidedly a great advantage whenever the residue is to be dried. That together with the somewhat higher washing efficiency will outweigh the labor item, which is in favor of the leaf-type filter. Moreover, the simplicity of replacing a leaky blanket is a matter not to be overlooked.

In connection with the description of the new filter press just given I intend to add a few suggestions concerning a standard method of putting down the work done by a filter. I think there can be no question as to the usefulness of such a scheme. Filtering is one of the most important operations in many chemical and metallurgical processes, and the machines are so numerous that figures computed in a like manner as to the work done by them would be most interesting and valuable. It would be of help to the engineer interested in some particular process, as well as to the man who is offering a machine for effecting the separation of a liquid from solid matter.

The data given before and which I used for comparing three different types of presses defined pretty well the performances of each machine. One figure relates to the amount of water needed for washing the cakes—no doubt in many cases the most important item—the second tells the condition of the discharged cakes, and the third data gives the amount of material handled per hour and per square foot filter area when operating continuously.

With regard to the amount of water required for practically complete extraction of soluble matter from the cakes, we often hear it expressed in gallons per ton of dry solids. While this is quite sufficient for one

familiar with the material worked to do some figuring, it conveys no direct impression as to how efficient washing is carried out. For this reason I prefer to base the calculation of this item on the displacement principle, calling the washing 100 per cent efficient if the volume of water required for practically complete extraction is equal to the volume of solution the cakes contain after they have been built up.

Figs 4, 5 and 6 illustrate this.

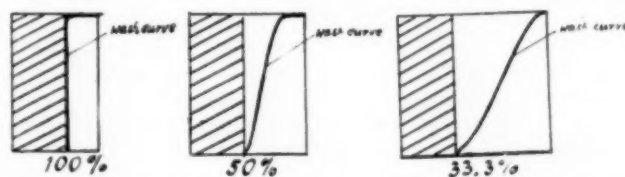
In Fig. 4 (100 per cent washing efficiency) the solution is pushed out of the cake with an equal volume of water.

In Fig. 5 (50 per cent washing efficiency) the solution is pushed out of the cake with twice its volume of water.

In Fig. 6 (33.3 per cent washing efficiency) the solution is pushed out of the cake with three times its volume of water.

A press doing a good work should at least show a washing efficiency of 50 per cent.

The final moisture content gives the amount of water



FIGS. 4, 5, 6—100%, 50%, 33.3% EFFICIENCY

remaining in the cakes when they are discharged. This data will assume importance in all cases where the material has to be dried.

The figure as to the amount of solids handled per square foot per hour is interesting as well as important. Interesting inasmuch as it shows—providing the washing efficiency is about equal—to how much those devices for mechanically discharging the cakes amount to; important, because it tells what size filter is required to handle a certain quantity of material in a given time.

68 Bay View Avenue, New Brighton, N. Y.

Platinum is worth about \$45 an ounce, against \$20 five years ago. The United States output of this metal in 1912 was only 721 ounces of crude metal. The world's output for that year was estimated by the Geological Survey to be 314,751 ounces, derived as follows: Russia, 300,000; Canada, 30; New South Wales, 500; Colombia, 12,000; United States, domestic crude, 721; United States, from foreign and domestic matte and bullion, 1300; Borneo, Sumatra and other, 200. The production of the more valuable metals in the United States in 1912, in short tons, is shown in the following table:

	Quantity	Value
Platinum .....	1,304	\$1,732,221
Gold .....	188,108	113,415,410
Silver .....	4,471.4	80,187,317
Aluminum .....	32,803.	15,089,380
Quicksilver .....	939.9	1,057,180
Nickel .....	22,421.	17,936,800
Tin .....	8.4	8,850
Copper .....	734,052.	242,337,160

The melting points of some copper alloys have been investigated by the United States Bureau of Mines, and the results are contained in *Technical Paper No. 60*. The following table contains results of many tests which checked within 5° C.:

Alloy	Deg. C.	Deg. F.
Gun metal .....	995	1825
Leaded gun metal .....	980	1795
Red brass .....	970	1780
Low-grade red brass .....	980	1795
Leaded bronze .....	945	1735
Bronze with zinc .....	980	1795
Half yellow, half red .....	920	1690
Cast yellow brass .....	895	1645
Naval brass .....	855	1570
Manganese bronze .....	870	1600

## The Russian Chemical Industry

[Special Correspondence from St. Petersburg]

The chemical industry in the Urals has been quite an exceptional business up till recently, partly because of the geographical position of that mining district, and partly because of the economic conditions existing there. If we leave out the industries of the Kam river district the products and by-products prepared at the Urals chemical works generally are consumed entirely by the local concerns, and only a relatively insignificant quantity is sent into the interior market and into Siberia. Only special products, such as bichromate, for which the district holds practically a monopoly in view of the favorable natural conditions, are exported to more distant European and Asiatic Russian markets.

On the other hand, exceptionally favorable conditions would exist for the production of sulphuric acid in the Urals, because of the deposits of pyrites and the fine quality; but is prepared on the spot in very limited quantities, almost exclusively for local requirements, such as the preparation of galvanized iron and the working of copper ores, etc. The relatively small quantity that reaches the markets for various small uses need not be taken into account. As far as is known, in the Urals factories sulphuric acid is hardly used for other purposes, nor are its salts or other derivatives. In truth, at present the general revival of industrial life in the Urals is finding expression in the production of sulphuric acid.

The creation of new galvanized iron factories is causing an extension of existing sulphuric acid factories, and the construction of new ones in the district. Besides this, the organic development of industrial life in the Urals finds its expression in various tendencies in the present chemical industry, showing that it is changing over to a new and more complicated development. The appreciation of the price of fuel, the high cost and insufficiency of labor, are now bringing certain chemical processes to the front which have resulted in the establishment of new chemical factories. As an immediate example we have in view the application of peat for the production of generator gas, and the establishments of dry distillation of wood on modern principles.

The application of peat for the production of generator gas under certain conditions of operation, yields various by-products, amongst these ammonia, which in combination with sulphuric acid, enters the fertilizer industry. One of the largest Urals concerns will shortly begin the extension of its sulphuric acid plant in connection with the production of ammonia from peat.

The question of establishing in the Urals an efficient factory for dry distillation of wood is largely dependent on the question of expensive fuel. The production of charcoal is usually done under very primitive conditions, and a large quantity of valuable products disappears together without profit. The establishment of dry distillation of wood under efficient conditions using the acetic acid and the wood spirit, and perhaps even turpentine, would make it possible to considerably reduce the cost of charcoal for metallurgical purposes.

Considering all these things, the government of the Kyshtim mining district is building a factory for the dry distillation of wood, which in a very short time will be started to work. It is easily understood that the establishment of all these new concerns intimately connected with the conditions of the present day development of the Urals mining industry, must result in the development of associated branches of the chemical industry; both for the purpose of providing the necessary raw materials, and for the further preparation of finished goods. On the other hand, a market must be

found for the products; for the Urals chemical industry hitherto has had to work within very narrow limits in this respect.

The most interesting development in respect to technical improvements is the tendency obvious at the moment to utilize the sulphur fumes from the copper roasting furnaces. If these sulphur fumes which are now liberated directly into the open air were taken and resolved into sulphuric acid we should obtain an immense quantity of this product at a very low price. Analogous conditions exist in Silesia, where the recovery of sulphurous gases obtained during roasting zinc blende has resulted in the formation of an immense sulphuric acid and superphosphate industry, which exports from Germany into all directions, to Russia, Austria-Hungary, Servia, Roumania, etc.

If it were possible to establish such an industry in the Urals in connection with the roasting of copper ores, the Russian market would be able to dispose of a colossal quantity of sulphuric acid—two or three times more than the existing demand for it in the country. At first, naturally, it would be difficult to place such a large quantity of acid; but it is thought a large quantity of sulphuric acid could find a relatively easy market in the superphosphate industries of the country in the near future. This is the direction which should be taken by those who are studying the question of waste sulphur fumes. Unfortunately information on the phosphate deposits of the Urals does not tend to encourage the hope of an early extensive establishment of a superphosphate industry there, to yield a cheap manure for our eastern and central districts, where it is so much wanted. In any case the first steps in this direction are now being taken, and judging from the information gathered over the widely extended area, including the Kyshtim mining district, it may be noted that the utilization of sulphur gases recovered from three copper roasting furnaces is already being effected, each of these furnaces burning 2500 poods of pyrites per day.

We are probably entering quite a new era in the development of the chemical industry of the Urals, particularly in reference to artificial manures. And although it is quite true that the analyses of the Urals phosphate deposits is not an encouraging one, they can still be used with a cheap sulphuric acid and produce a superphosphate which will be of greater relative value to the local agriculturist than would be a richer manure after having to pay the enormous cost of transportation from Western or Southern Russia. Thus while Southern Russia becomes an exporter of sulphate of ammonia the Urals is probably entering into a state of independence with respect to artificial fertilizers, which are two very notable developments in the Russian chemical industry.

The Arizona Copper Co. produced, during December, 1913, 1460 tons of copper.

The Thomas Mellen Company, Portland cement manufacturers, Jamesville, N. Y., have broken ground for their new cement stock-house and expect to be able to run cement into the same before February 1, 1914. The building will be of steel and concrete with self-emptying bins. At one end will be located a pack house equipped with Bates-Valve soaking machines. This will be the first of extensive additions to be made to the plant in the next year. Owing to the high quality of the product and the consequent popularity of the brand in Syracuse, Rochester and northern central New York, the company has found the enlargement of their plant necessary. Richard K. Meade, chemical, mechanical and industrial engineer, 203 N. Calvert Street, Baltimore, Md., has been retained as engineer and prepared the plans and specifications for the new stock house.



## Extinguishing of Fires in Volatile Liquids\*

BY EDW. A. BARRIER

The extinguishing of fires in oils and in most of the volatile liquids has always been a difficult problem, and where fires of this kind occur the results are frequently very disastrous. Our most common extinguishing agent, water, works rather unsatisfactorily upon the majority of such fires, but it is still the only one available where heroic measures are required. Comparatively recently, however, there have been two or three other materials introduced for use as extinguishers which have shown some promise for dealing with these fires.

Not all fires in volatile liquids are difficult to handle with water. When the liquid is miscible with water this extinguishing agent can be successfully used. Examples of this kind are denatured alcohol, wood alcohol, grain alcohol, acetone, etc. Where the liquid is not miscible with water little or no effect is produced except to wash the burning liquid out of the building where it may be completely consumed or, if the quantity of oil is small, possibly to extinguish the fire by the brute cooling effect of a large quantity of water sprayed upon the fire. Soda and acid extinguishers are somewhat more effective than pure water, but even they fail under most conditions. The various grenades containing salt solutions which were formerly extensively exploited are, of course, practically worthless.

The only principles that can be made use of in extinguishing fires in volatile oils are, (a) to form a blanket either of gas or of solid material over the burning liquid which will exclude the oxygen of the air, or, (b) to dilute the burning liquid with a non-inflammable extinguishing agent which is miscible with it.

### Sawdust and Bicarbonate of Soda

To the blanketing type of extinguishers belong sawdust. Paradoxical as it may seem, ordinary sawdust is an excellent extinguishing agent for certain volatile liquids, especially those of a viscous nature. A considerable number of experiments were conducted in the fall of 1912 by the inspection department of the Associated Factory Mutual Fire Insurance Companies, in the extinguishing of fires in lacquer and gasoline in tanks with sawdust, and the results were surprisingly satisfactory.

The liquids were placed in three tanks 30 in. long, 12 in. wide and 16 in. deep; 48 in. long, 14 in. wide and 16 in. deep, and 60 in. long, 30 in. wide and 16 in. deep. The sawdust was applied with a long-handled, light but substantially built snowshovel having a blade of considerable area. In every case the fires were extinguished readily, especially in the two smaller tanks, which were about as large as any ordinarily employed for lacquer in manufacturing establishments.

The efficiency of the sawdust is undoubtedly due to its blanketing action in floating for a time upon the surface of the liquid and excluding the oxygen of the air. Its efficiency is greater on viscous liquids than on thin liquids, since it floats more readily on the former than on the latter. The sawdust itself is not easily ignited and when it does become ignited it burns without flame. The burning embers have not a sufficiently high temperature to reignite the liquid.

The character of the sawdust, whether from softwood or hardwood, appears to be of little or no importance, and the amount of moisture contained in it is apparently not a factor, so that the drying out of saw-

dust when kept in manufacturing establishments for a time would not affect the efficiency.

It was found that the admixture of sodium bicarbonate greatly increased the efficiency of the sawdust, as shown both by the shortened time and the decreased amount of material necessary to extinguish the fires. A further advantage of the addition of bicarbonate of soda is that it decreases the possible danger resulting from the presence of sawdust in manufacturing plants since it would be difficult, if not impossible, to ignite the mixture by a carelessly thrown match or any other ready source of ignition.

Although the efficiency of the sawdust is greatest on viscous liquids such as lacquers, heavy oils, japan, waxes, etc., in the tests referred to, fires were extinguished in gasoline contained in the smallest tank and also when spread upon the ground. In larger tanks the sawdust or bicarbonate mixture does not work so well since the sawdust sinks before the whole surface can be covered, whereupon the exposed liquid reignites.

### Carbon Tetrachloride

In recent years carbon tetrachloride has received considerable attention as a fire-extinguishing agent. This is due largely to the activity of certain manufacturers of fire extinguishers which use liquids, the basis of which is carbon tetrachloride.

This substance is a water-white liquid and possesses when pure a rather agreeable odor somewhat similar to chloroform. A considerable proportion of the commercial article upon the market, however, contains sulphur impurities which impart a disagreeable odor to the liquid. The substance is quite heavy, its specific gravity being 1.632 at 32 deg. Fahr. It is non-inflammable, non-explosive, and it is readily miscible with oils, waxes, japan, etc. When mixed with inflammable liquids it renders them non-inflammable provided a sufficient quantity is added. Its vapor is heavy, the specific gravity being about five and one-half times that of air, consequently it settles very rapidly.

As an extinguishing agent it operates by both the principles mentioned above, namely, it diluted the inflammable liquid rendering it non-inflammable, or at least less inflammable, and it forms a blanket of gas or vapor over the burning liquid which excludes the oxygen of the air.

It may not be out of place to mention that the claims made by certain manufacturers producing extinguishers which use liquids, the basis of which is carbon tetrachloride, are grossly exaggerated. These preparations, none of which is more efficient than carbon tetrachloride, are not the equivalent of the ordinary water extinguishers for general use on such materials as cotton, wood, paper, oily waste, etc.

On volatile liquids, oils, etc., carbon tetrachloride has, however, shown very satisfactory results under some conditions, but the readiness with which a fire can be extinguished with it depends to a considerable extent upon the skill of the operator and the nature of the fire. In tank fires the length of time that the liquid has been burning is an important factor, and in such cases where the sides of the tank become heated the only way in which the fire can be extinguished is to squirt the liquid forcibly at the sides. If the carbon tetrachloride is squirted directly into the liquid it is much more difficult, if not impossible, to extinguish the fire.

The height of the liquid in the tank is also a very important factor. Where the liquid is low the sides form a pocket which retains the vapor and aids considerably in smothering the blaze. When the tank is nearly full, however, this condition does not exist, and

\*Slightly abstracted from the December, 1913, issue of the Journal of the American Society of Mechanical Engineers. The author is a member of the Inspection Department of the Associated Factory Mutual Fire Insurance Companies, Boston, Mass.

it is then very difficult, if not impossible, to extinguish a fire in a highly volatile liquid, such as gasoline; only the most skilled operators are successful in these cases. The size of the tank or the extent of the fire if upon the floor is, as would be expected, of considerable importance. In tanks larger than about 28 in. by 12 in. more than one extinguisher and operator working at a time are necessary to extinguish a fire in such materials as gasoline. In one test where a tank 60 in. by 30 in. was used no less than seven operators were necessary, and even then it was only with the greatest difficulty that the fire was put out.

All of the above remarks apply to carbon tetrachloride in the ordinary one-quart extinguisher as generally sold. It is probable that a large extinguisher which could throw a large stream would prove more efficient, but on account of the great weight of carbon tetrachloride such an extinguisher would have to be specially designed to make it readily portable by mounting on a truck or some similar means. Expelling the liquid by means of a hand-pumping arrangement would probably be unsatisfactory, and it would, therefore, be necessary to force it out in some other way.

A few systems have recently been installed in which an elevated tank containing carbon tetrachloride was connected with automatic sprinklers or perforated pipes located in hazardous rooms where volatile and inflammable liquids are in use. So far as is known none of these systems have as yet been called upon to extinguish a fire, but there appears to be no reason why such a system should not provide excellent protection in special cases. In such systems it would be necessary to consider the safety of the workmen and furnish ready means of escape, since carbon tetrachloride is an anesthetic and where thoroughly sprayed through the air, as from an automatic sprinkler, it would probably produce rapid results.

The nature and effect of the fumes given off when carbon tetrachloride is thrown upon a fire is a subject which has received a great deal of discussion. When the liquid comes in contact with a fire the vapor is partly decomposed, resulting in the evolution of a considerable quantity of black smoke which is undoubtedly finely divided carbon. Pungent gases are also produced which appear to be mostly hydrochloric acid, with possibly a small amount of chlorine. Since carbon tetrachloride contains no hydrogen from which hydrochloric acid could be formed, this substance must be produced by the action of chlorine on the gases arising from the burning material or upon the moisture of the air.

The fumes of carbon tetrachloride, although of a very pungent nature, do not produce any permanent injury under ordinary conditions where the operator can make his escape after he has inhaled all he can stand, but they are distinct handicaps in fighting a fire and are one of the objectionable features to carbon tetrachloride as a general fire extinguishing agent. In large rooms or where a small quantity of carbon tetrachloride is sufficient to extinguish a fire, the gases are, of course, less objectionable.

#### Frothy Mixtures

Another method of extinguishing fires in oils and volatile liquids which has recently been proposed and experimented with is that of using frothy mixtures. The idea seems like a very promising one and the tests which have been thus far reported indicate very satisfactory results. The idea was originated and has been developed in Germany. So far as is known no experiments have been conducted in this country.

The process consists essentially in causing two liquids to mix in a tank where foam is produced. The tank is made airtight and sufficiently strong to permit of the

foam being forced out by carbon dioxide under pressure, and the foam is conveyed to the fire by means of a line of hose. The exact nature of the liquids has not been disclosed, but one of them probably consists of a sodium-carbonate solution containing froth-forming ingredients such as glue or casein and the other an alum solution. The two on coming together generate carbon dioxide which produces froth. This froth is reported to be quite stiff and to shrink in volume but a comparatively small amount even after a period of half an hour.

A number of tests were conducted in the winter of 1912 in Germany; some of them on a considerable scale. In one case as much as 5 tons of crude naptha in a tank was involved, and in another an area of 1300 sq. ft. of burning tar was used. In all cases the results were reported satisfactory, the fires being extinguished in a short time.

The frothy mixture undoubtedly owes its efficiency to its blanketing action in settling upon the surface of the burning liquid, thus excluding the oxygen of the air, and to the fact that the bubbles of liquid contain carbon dioxide which upon bursting produce an atmosphere in which combustion cannot take place.

According to the latest reports the matter is still in an experimental stage, various details regarding the form of apparatus, most efficient pressure and design of nozzles being under consideration; but from what has already been done it would appear that the idea is a very promising one, and that this method of extinguishing fires in oils and volatile liquids will prove to be by far the most efficient of any that has as yet been suggested.

#### Efficiency Exposition

The first national Efficiency Exposition and Conference will be held in the Grand Central Palace, April 4 to 11, inclusive, 1914. Its aim and purpose will be to give living expression to the increasing application of scientific methods to modern conditions.

The plan and scope of the show will include displays of efficiency appliances, methods and products in industrial, mechanical, governmental, educational and household fields. Not the least interesting feature of the show will be a series of mental and manual efficiency contests which will be staged along original lines and conferences and illustrated lectures on subjects of vital current interest.

The exposition will be held under the auspices of the Efficiency Society and in conjunction with the conferences of the Society and other scientific organizations.

Mr. William R. Wilcox, ex-chairman of the Public Service Commission, will, as president of the Efficiency Society, preside over the exposition which includes on its Advisory Committee such well-known names as F. H. Bethel, vice-president New York Telephone Company; James G. Cannon, president Fourth National Bank; Norman Hapgood, editor Harper's Weekly; William A. Marble, president Merchants' Association of New York; William A. Prendergast, comptroller City of New York; Lawson Purdy, president Department of Taxes and Assessments; Elbridge G. Snow, president Home Insurance Company; Arthur Williams, general inspector New York Edison Company; T. S. Williams, president Brooklyn Rapid Transit Company; Joseph French Johnson, dean New York University. Travis H. Whitney is the chairman of the Executive Committee.

Leadville's metal production for 1913 was valued at only \$9,040,350, being about \$2,000,000 less than for 1912. The total tonnage of ore mined was 453,360, of which 1/3 was zinc carbonate. The grand total value of Leadville's production to date is calculated locally as \$406,451,061.



## Nitrates by Electrolysis of Peat

In an article in London *Electrical Review*, of December 19, 1913, Mr. Georges Dary describes a new scheme for utilizing peat deposits. The object is to produce from them nitrates by electrolysis. The inventor is Albert Nodon, the French electrical engineer, who has formerly become known by his work on the electrolytic aluminum valve. We quote the description of the process verbatim from the article of Mr. Dary.

"M. Albert Nodon has continued the research work of Mr. Müntz, and, as a result of long and exhaustive tests, has recently discovered an extremely economical process of extracting nitric acid and nitrates by treating peat deposits electrolytically. The process has recently been patented in the United Kingdom, to which country it is especially suited. By its means calcium nitrate, which is formed in considerable quantities and continuously in peat deposits can, in fact, be decomposed by electrolysis, the nitric acid passing to the

anode, which is enclosed, while the lime accumulates about the cathode.

"The operation is effected automatically and continuously by means of a simple and cheap plant installed in the open air directly on the peat deposits, this accounting for the fact that the cost of production is practically

restricted to that of the current consumed. The Nodon process, in fact, renders the usual heavy expenditure for the extraction, transport, and lixiviation of the peat entirely unnecessary, thus overcoming all the drawbacks which lead to the rejection of the Müntz scheme.

"The industrial arrangement of the Nodon method may be outlined as follows: Porous pots, filled with coke, which is utilized as the anode, and a weak solution of nitric acid, are installed at equal distances directly in the peat deposits. The nitric acid obtained by the electrolysis of the nitrates of the earth is gathered into tanks, while the lime resulting from the decomposition into calcium nitrate is collected by the cathodes, which latter consist of iron rods sunk into the deposits. Each anode element (Fig. 1) consists of a cylindrical porous pot *a*, of coarse pottery, rendered porous by the addition, before baking, of a paste of combustible dust. The pots which are 8 ft. 2 in. in height x 15 3/4 in. in diameter are sunk into holes dug in the peat, care being taken to tightly ram the earth below in order that there shall be no movement in the pots. Each of the latter is filled with washed coke, a large rod of graphite *c* being placed in the center of the same, its center being to convey to, and distribute, the positive current through the coke.

"It is very necessary that a perfect joint should be made between the graphite rod and the electric cable, as in batteries; with the view of ensuring this, the upper end of the rod is coppered, lead being cast between this and the end of the coppered conductor. Two glass tubes *d* and *e* project into the porous pot. The tube *d* extends practically to the bottom, while the other only penetrates just below the surface of the liquid. The object of the first tube is to draw off the water impregnated with nitric acid; while the tube *e* serves to replenish the pot with an amount of water

equal to the liquid drawn off. Round each pot a circular space *f* is left, which is filled with calcium carbonate, or simply broken limestone. Stakes of tarred wood *g* separate the peat from the annular space, which forms a sort of cage for the limestone.

"The cathodes or negative poles *h* are of rough cast iron, and are of a square bar section, 8 ft. 2 in. in length. The upper end *i* is made of a cup shape, into which antimoniated lead is poured, in order to make a good connection with the conductor *j*. The whole is carefully tarred with the view of obviating any destructive action. The rods are located at a distance of approximately 4 in. from each other, and are connected to a common conductor *k* (Fig. 2). In this way a cathode of a large surface is secured.

"The porous pots are fixed at a distance of 3 ft. 3 in. from each other, the shortest space between any of the anodes and cathodes being 1 ft. 7 1/2 in.

"As soon as the current is switched on, the following phenomena are observed: The ground of the peat bog may be regarded as an electrolyte, the specific resistance of which has been found equal to an average of 3 ohms per meter cube. This resistivity necessitates the employment of a pressure of 10 volts in order to secure sufficient current density. Under the action of this current nitric acid is produced at the anode, and lime at the cathode. . . .

"The nitric acid remains dissolved in the porous pots *a*; the solution is drawn off along the tubes *d*, and conveyed to a large storage tank by means of pumps *n*, water being admitted by tubes *e* to make up for the liquid extracted. The solution may be directly concentrated in sandstone evaporators, in order to produce pure nitric acid, for which there is a large demand. . . . The free acid is usually saturated with calcium

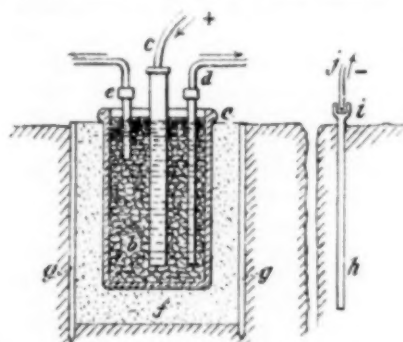


FIG. 1—ANODE AND CATHODE ELEMENTS

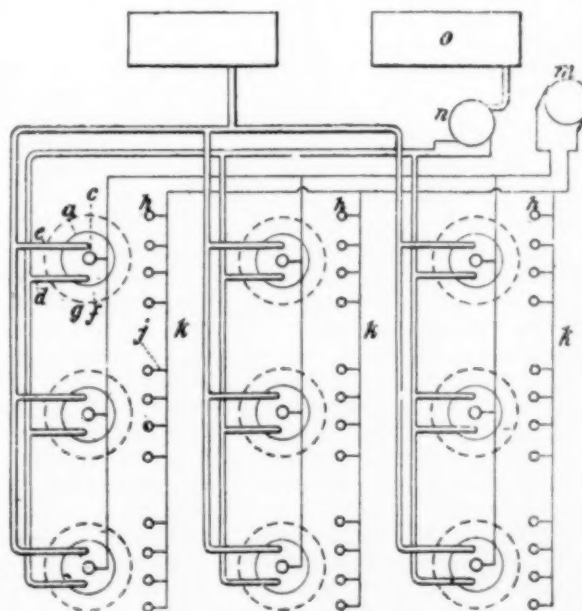


FIG. 2—ARRANGEMENT OF ELECTROLYTIC CELLS

carbonate. The solution is evaporated in boilers fired with dried peat, a calcium nitrate, similar to that supplied for agricultural purposes, being obtained by crystallization.

"Peat is particularly adapted for the intensive production of pure nitrate; in fact, 2 per cent of its weight consists of nitrogen capable of being converted into fixed nitrogen under the simultaneous action of the nitric ferments, the oxygen of the air contained in the porous mass of peat, the hygrometric water and the heat developed by the passage of the electrical current.

"The flow of the current in the peat does not sensibly reduce the activity of the nitric ferments, so long as the density per unit of surface of electrodes is not too high.

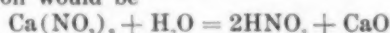
"It is thought advisable to mix calcium carbonate with the peat, or, simply, a lime milk resulting from the lixiviation of the lime, which accumulates round the cathodes. Without this precaution the peat becomes impoverished as regards calcium, and the nitric ferments will quickly commence to act on the ground rendered acid by the free nitric acid. It is also well to prevent the development in the nitrate bed of ferments capable of paralyzing, as it were, the action of the nitric ferment; this can be done by distributing, by means of a pump, separately-prepared ferment solutions.

"All these operations can be effected quite economically by means of electrically operated pumps and distributing pipes fixed on the peat deposit.

"It has been found that the nitric ferment attains its maximum degree of activity at 25° C., while a continuously flowing current at a pressure of 10 volts is amply sufficient.

"A deposit of peat, having a depth of 6½ ft., and an average richness in nitrogen of 2 per cent, can produce between 800 and 900 tons of pure nitrates per year; while, according to the research work of M. Müntz, if the deposit is located near a town, and can be watered with liquid manure, it can be made to yield 6,000 tons of fixed nitrogen."

In the article an equation of the reaction is given which is clearly wrong. If the reaction as claimed is really the electrolytic decomposition of calcium nitrate, the equation would be



corresponding to a passage of  $2 \times 96,540$  coulombs, if the symbols in the equation represent gram-molecules. Theoretically,  $2 \times 96,540$  coulombs would, therefore, produce 126 grams  $\text{HNO}_3$  or one amperehour 2.4 grams of  $\text{HNO}_3$ .

According to the article 1 amperehour gives 1 gram  $\text{HNO}_3$ , so that the current efficiency is 42 per cent.

Since according to the article the voltage per cell is 10 volts, 1 kw-hour produces 240 grams of  $\text{HNO}_3$ .

In Mr. Dary's article it is stated that for the most efficient operation 2500 porous pots and 36,000 iron rods are required per hectar (1 hectar = 2.47 acres) with a current density of 3.33 amperes per square meter of anode surface, or a current of 7.5 amperes per porous pot. Hence the current per hectar is 18,000 amperes. The production per 24 hours would, therefore, be  $18,000 \times 24$  grams or 950 lbs.  $\text{HNO}_3$  per hectar with a power consumption of 180 kw and an energy consumption of 4320 kw-hours.

In order to use energy supply at 100 volts, the peat deposit is divided into ten parallel trenches, electrically connected in series in such a way as to give a difference of potential at the two extremities of 100 volts, while using only 10 volts in each of the separate trenches.

Mr. Dary's article contains also a cost estimate, prepared by Mr. Nodon, for a plant for the electrolytic extraction of 100,000 tons of nitrates per year, but as it is only an estimate and based on European conditions, it is not reproduced here. The important figures claimed for the process are that the production of 1 kilogram of  $\text{HNO}_3$  requires 1000 ampere-hours and 10 kw-hours.

The National Association of Manufacturers of Medicinal Products will hold its annual convention on February 10th in New York City.

## Ductile Tungsten Patent

What must be considered as the fundamental patent for making ductile tungsten has now been issued. It is patent No. 1,082,933, granted on Dec. 30, 1913, to Dr. William D. Coolidge, of Schenectady, N. Y., and assigned to the General Electric Company. It relates to "Tungsten and Method of Making the Same for Use as Filaments of Incandescent Electric Lamps and for Other Purposes." The serial application in this case, filed June 19, 1912, was in part an extension of four prior applications, the earliest under date of July 2, 1906. The invention covered by this patent is the now well-known ductile tungsten for incandescent-lamp filaments and other uses, which was discovered in the research laboratory of the General Electric Company.

One of the interesting features of this patent is its history in the Patent Office. The primary examiner rejected the entire application on the ground of prior disclosures in British patents No. 21,513 of 1906, No. 3174 of 1907, No. 16,530 of 1907 and No. 24,179 of 1906. The examiner also held that certain claims should be divided, under another application, and that some of the other claims were duplicates in patentable effect. In a decision of the board of examiners-in-chief, filed on Nov. 15, 1913, the citation of the first three British patents named above was rejected on account of their having been filed subsequent to July 2, 1906, the earliest filing date in the Coolidge application. The members of the board also dismissed the other contentions of the primary examiner except as to duplication of claims, and the latter ruling was over-ruled by the examiner-in-chief, so that the original application was finally allowed intact.

Out of the thirty-four claims in the patent we quote the following:

"1. The process of producing tungsten having a fibrous structure which consists in repeatedly hot-working a crystalline body of tungsten until the crystalline structure is broken down and a fibrous structure developed.

"2. The process which consists in agglomerating tungsten powder, sintering the body thus formed, subjecting it to repeated hot-working, and continuing such hot-working until the body remains ductile when cold.

"8. The method of producing pliable tungsten wire for lamp filaments, which consists in first producing a body of tungsten in a sintered state and free from oxygen carbon and other impurities which would render the body unworkable mechanically and then subjecting this sintered and purified body to mechanical working many times repeated, with gradual reduction in diameter and elongation in length.

"12. The process which consists in reducing tungsten oxide to coarse tungsten powder, agglomerating said powder into a coherent porous body, heating said body to drive out impurities and sinter the body, and then subjecting the body to hot mechanical working.

"14. The process which consists in forming a body of tungsten powder containing additional material which will prevent coarse crystallization of the tungsten at high temperature, sintering the body and then subjecting it to hot mechanical working.

"22. The method of securing a ductile metal body without previous melting of the metal, which consists in producing a compact body of metal from divided metalliferous material, consolidating said body by heating to a temperature less than the melting temperature and such as to produce a body of metal non-ductile when cold, subjecting the body to repeated mechanical working while in a heated condition, and continuing the working until the body is ductile without the application of heat.



## The Kieselguhr Industry

BY PERCY A. BOECK

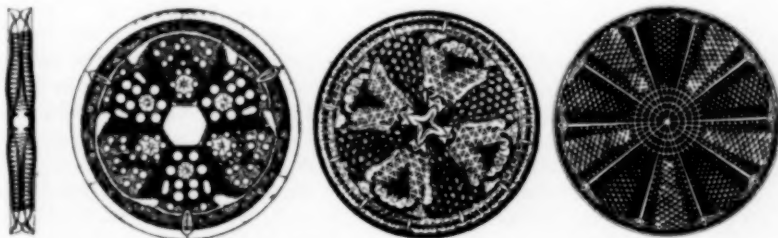
Many of the uses of kieselguhr, also known as diatomaceous earth, Tripoli, Sil-O-Cel, and sometimes as infusorial earth, have long been known. The ancient Greeks and Romans made the so-called "swimming brick" and the emperor Justinian, in 522 A.D., ordered the dome of the Hagia Sophia built of brick made of this material to lighten the weight of the structure.<sup>1</sup>

Since that time the applications of this material have increased in an almost endless variety of uses. It has not been until recently, however, that the use of kieselguhr in the industries has been developed systematically. This has been brought about to a great extent by the present-day keen competition, which has compelled closer attention to by-products and wastes, and by the ever-increasing tendency toward efficiency in industrial plants through the reduction of losses from all sources to the lowest possible point.

The available technical literature dealing with kieselguhr is not only limited in amount, but it is widely scattered and generally inaccessible. It is not the purpose of this article to attempt to enumerate or catalog all of its various uses, but rather to summarize and discuss briefly its nature and properties in such a way as to bring out the principal applications of this important, and, in this country, somewhat neglected mineral.

### Formation

Kieselguhr deposits are formed by the precipitation of the remains of bacillariæ or diatoms, one of the groups of flowerless aquatic plants of the species



FIGS. 1 TO 4.—DIATOMS LARGELY MAGNIFIED

"algæ," which occur almost universally in all waters from arctic to torrid, fresh or salt, still or running. There are innumerable varieties of diatoms, over 4000 distinct forms having been classified and described. These vary greatly in size from that of a head of a pin easily visible to the naked eye, down to such a minute size as to be revealed only by the highest power of the microscope.

The silica shell or casing of these plants is secreted by the assimilation of inorganic substances in solution in the water about them through the agency of sunlight in conjunction with the chlorophyll masses which compose the bodies of the plants. Diatoms multiply with great rapidity and float about in the water or on its surface while living. When the organism dies it sinks to the bottom where the countless myriads of shells accumulate, carrying down with them varying amounts of undecomposed organic matter of which a part remains even centuries after.

The valves or shells of which there are always two exact counterparts are in many instances elaborately carved and ornamented with the most intricate and delicate designs of marvellous variety, which make these plants the most ornate of all living organisms,

and has properly earned for them the title of "Jewels of the Plant World." A magnification of from 200 to 500 diameters is usually sufficient to reveal the finer and more delicate tracings on these shells, but occasionally much higher magnifications are necessary. The microphotographs shown in Figs. 1 to 4 give some idea of the variety and nature of diatoms in American samples of kieselguhr.

### Composition of Kieselguhr

The accumulations of these diatomaceous shells is in most deposits contaminated by interposed impurities which also settle to the bottom of bodies of water or are carried along with the sinking diatoms. This may be in the form of diatomaceous ooze, silt, clay, sand or volcanic ash and other inorganic materials from which it is commercially impossible to separate the diatoms. In a few deposits such as that which is found near Lompoc, California, the diatoms occur in enormous beds of unusually pure and uncontaminated kieselguhr. Analysis of several materials from this deposit show the following composition on the moisture free basis:

Sample	(1)	(2)	(3)
(1) Very light-weight pure white kieselguhr.			
(2) Light-weight brownish kieselguhr.			
(3) Compact diatomaceous shale.			
Silica (SiO <sub>2</sub> )	88.78%	85.28%	94.59%
Alumina (Al <sub>2</sub> O <sub>3</sub> )	2.68	5.35	1.87
Iron oxide (FeO)	trace	1.12	.76
Titanium oxide (TiO <sub>2</sub> )	0.10	0.21	0.10
Lime (CaO)	1.61	1.12	.83
Magnesia (MgO)	1.30	1.30	trace
Loss on ignition	5.54	5.57	2.22
Color	White	Ivory	White
Color after ignition	White	Pink	White

In its natural state kieselguhr contains from 25 to 45 per cent of moisture which is expelled at 100 deg. C.,

and is pure white to brownish, very light weight, soft, easily abraded material. The condition of the silica, its principal constituent, is one of the characteristic properties, it being in the amorphous or opaline state carrying ordinarily from 5 to 10 per cent of combined water. In many cases this silica has been erroneously reported by some of the older writers as "colloidal silica," this term being used synonymously with amorphous silica, due in all probability to the vague understanding of the term. This,

however, must not be taken to indicate that kieselguhr has no colloidal properties, for as a matter of fact these properties are strongly marked but variable, similarly as in a great many clays and show a decided absorption with malachite green oxalate. In certain cases a higher absorption of this dye is obtained by kieselguhr than on samples of Fuller's Earth, in which the bleaching or clarifying action has been shown to be due to a large extent to the physical condition of absorption and dependent on the colloidal content of the earth.<sup>2</sup> The condition of the silica in kieselguhr is further indicated by the fact that it is easily decomposed by means of hydrofluoric acid, is soluble in solutions of sodium carbonate of all strengths and yields water on heating in a closed tube. The specific gravity of kieselguhr is approximately 2.1 to 2.2 at 25 deg. C.; indicating that it is amorphous silica, which is usually taken as 1.9 to 2.3.

### Lompoc Deposit

The geology of this deposit has been studied extensively by Mr. W. B. Schilling, E. M., who gives the following description: The deposits of kieselguhr of Northern Santa Barbara county, California, are largest and best of any known deposits and of great impor-

<sup>1</sup> D. Toepf. und Ziegl. Ztg., 1876, pp. 92, 148.

<sup>2</sup> Mann: Smithsonian Miscell. Coll., v. 48.

<sup>3</sup> C. L. Parsons: Mineral Technology, Bureau of Mines, Bul. 71.

tance because of their pure state and workable condition. In the region immediately south of Lompoc there occurs a deposit of literally mountains of this material owned privately in one tract almost chemically pure and covering an area of many square miles. Fig. 5 shows a mountain of kieselguhr at Lompoc, California.

This deposit occurs in the Monterey or Middle Miocene formation. All gradations from the soft diatoma-



FIG. 5—A MOUNTAIN OF KIESELGUHR AT LOMPOC, CAL.

ceous material to the hardest of black flints may be found, thus indicating the extreme localization of the conditions that produced the harder varieties from the unaltered deposits. In some places the material is in great soft masses in which the bedding cannot be recognized except by the characteristics weathering into flakey layers parallel with the original bedding planes. Everywhere else it is more compact and in thin beds, ranging from one-half an inch to two and three inches in thickness, or in massive beds. The beds are tilted and in conformity with the much disturbed hard bed of flinty shale of the lower portion of the Monterey formation, of which the whole series is a part. The least known thickness of this deposit in a pure state is 700 feet.

#### Mining and Milling

The mining or quarrying of this material is carried on by means of an open face workings where the kieselguhr is taken up in huge blocks. (See Figs. 6 and 7.) This operation is made easier where transverse seams occur in the strata, due to local folding. Where these seams do not occur it becomes necessary to loosen the kieselguhr slightly by means of powder before the blocks can be removed from the quarry face.

Owing to the peculiar physical structure of the kieselguhr it has for ages been absorbing the surface waters and it is necessary that the material be split into convenient blocks for piling and drying, as shown in Fig. 8. The amount of absorbed water is about 25 to 45 per cent by weight and owing to the winds and dryness of the atmosphere of Southern California, this amount is reduced to about 5 per cent by natural air drying within forty to fifty days.

After drying the kieselguhr is hauled by means of motor truck to the reduction works where it is reduced and transferred by means of a pneumatic system to the different warehouses. It is likewise drawn to the finishing mill from the warehouse by this means and ground and blown into the several grades used commercially. When blocks are required the material is transported in its natural state direct from the quarry, sawed into the sizes required for building purposes and dried before shipment. Waste material too fine to be dried is utilized in the making of brick, tile and other refractory materials of light weight.

#### Properties of Kieselguhr

The general characteristics which make kieselguhr of great commercial importance for various purposes may be outlined as follows:

##### I. Physical.

###### (a) Form.

- (1) Enclosed air cells.
- (2) Large exposed surface of cells.
- (3) Fine state of division.
- (4) Sharpness of cells.
- (5) Weakness or low compressive strength of cells.

###### (b) Refractory nature.

###### (c) Presence of large amount of colloidal material.

###### (d) White color.

##### II. Chemical.

###### (e) Siliceous or inorganic nature.

###### (f) Easy solubility in alkalis.

###### (g) Insolubility in acid or neutral solutions.

The detailed description of these properties will be taken up in connection with the most important of the applications which depend on the specific property under consideration.

#### I. Physical Properties

##### 1. ENCLOSED AIR CELLS

The highly porous condition of the diatoms is shown in the microphotographs of Figs. 1 to 4; they, however, do not indicate the extent of this most important property as well as the statement of the amount of solid material in a unit volume.

*Light Weight.*—The apparent specific gravity of the raw blocks, as they are mined, after drying, varies considerably, depending upon the amount of material transformation which has taken place at the particular deposit. The apparent density of the dry, crude blocks is about 0.45 equivalent to 28 pounds per cubic foot, while that of the pulverized material, made from them, when loosely packed, has an apparent density as low as 0.13, equivalent to 8 pounds per cubic foot, which can be doubled with packing. In other words, in one cubic foot of the loose material there is but 0.058 of a cubic foot or 100.2 cubic inches of silica having a density of 2.2.



FIG. 6.—AN OPEN KIESELGUHR QUARRY FACE

*Filler or Diluent.*—This unusual bulkiness and light weight makes this material an excellent filler or addition agent for increasing the volume of materials largely without appreciably increasing their weight, and has found extensive application in the manufacture of light-weight tile, brick, partition-tile and as a filler for almost any character of bonding material. As an addition to portland cement it has been found that the strength is increased particularly on aging and completely preventing the destructive action of sea water



(Feret test for durability) for more than two years.<sup>4</sup>

**Thermal Insulator.**—The microscopic voids or "dead air" cells in and between the diatoms form an excellent natural barrier to the passage of heat making it the most effective inorganic thermal insulator known. This application is one of the oldest and most important of the uses of this material. The thermal conductivity of the dry natural kieselguhr block, loosely packed kiesel-



FIG. 7.—QUARRYING KIESELGUHR IN CALIFORNIA

guhr, and of the kieselguhr insulating brick and firebrick have been found to be as given in table I, the values for the conductivity  $k$  being given in gram-calorie seconds, i. e., the transfer of heat between opposite faces of a centimeter cube at a rate of one gram-calorie per second per each degree of centigrade difference in temperature of the faces at the temperatures indicated.

This most important property of kieselguhr has been used extensively for the production of fireproof and incombustible insulator in the form of loose powder, solid natural blocks, burned insulating brick and tile, pipe covering, etc., for both high temperatures in ovens, cookers, furnaces, annealing pits, boilers, evaporators, stills and for low temperatures in cold storage and refrigeration plants, icehouses, iceboxes, coolers and similar purposes. It has the advantages over the organic insulating materials, some of which have a somewhat higher thermal resistivity in that it is unaffected by extreme heat or cold, and is not subject to decomposition, decay or any physical change with time.

**Sound Deadener.**—On account of the same physical properties this material has found extensive use as a "deadener" or sound proofing material in and between the walls and floors of apartment houses, office buildings, school houses, booths, hospitals, etc.

**Absorbent.**—The high porosity of kieselguhr has further brought about its use as an absorbing medium for a variety of materials wherever it is desirable to give the properties of a solid to a liquid or semi-solid material; or in the recovery of waste liquors or by-products not readily available or handled with facility

form. It has also been used for an absorbent or vehicle for liquid disinfectants which are evolved slowly rendering them active for a long period of time.

**Filter.**—For the filtration of liquids the porosity of kieselguhr plays an important part, not only in mechanically retaining the finest suspended matter in the solution, but also aiding materially in keeping the filtering medium and deposited material in an open, porous state, preventing sliming and clogging, producing open, easily handled filter cakes of considerably increased filtering capacity. In the sugar industry both in Europe and in this country, kieselguhr finds almost universal application.

For the filtration of oils, excellent results have been obtained in certain cases by substituting kieselguhr for Fuller's Earth wholly or in part. This is due, in all probability, to a large extent to the high percentage of colloidal material in kieselguhr, as well as to its open and porous structure. Filters of bonded burned kieselguhr have been in use for many years, both abroad, where they originated, and in this country.

In a report on these filters Dr. Martin Kuchner states that filters of this material are four times more efficient than any similar filter as to quality and quantity of filtrate. In a test, bacteria appeared in the filtrate after three days in an ordinary filter, while in the case of kieselguhr no bacteria were found in the filtrate, even after six days of continuous operation without cleaning.<sup>5</sup> These filters are now used exclusively in the preparation of serum, toxines and products of a similar nature. They have lately also come into extended use



FIG. 8.—KIESELGUHR CORDED OUT TO DRY

in the removal of moulds and ferments from beers and fermented liquors.

## 2. LARGE EXPOSED SURFACE OF CELLS

The large surface presented by the kieselguhr diatoms has brought about its use as a carrier for the active material in several catalyzing processes, notably in the hydrogenation of unsaturated oils, in which pro-

TABLE I—THERMAL CONDUCTIVITY OF KIESELGUHR PRODUCTS in Gram-Calorie Seconds at Various Temperatures

	Apparent density	200° C.	300	400	500	600	700	800
Natural kieselguhr block (dried).....	0.53	0.000227	0.000259	0.000276	0.000287	0.000298	0.000308	0.000315
Pulverized kieselguhr (loosely packed).....	0.12	0.000127	0.000187	0.000248	0.000294	0.000332	0.000364	0.000397
Kieselguhr insulating brick (burned).....	0.75	.....	0.000448	0.000480	0.000510	0.000542	0.000573	0.000604
Kieselguhr firebrick (burned).....	1.05	0.000371	0.000472	0.000553	0.000623	0.000683	0.000738	0.000791

cess, for example, cottonseed or other vegetable oils are converted into the consistency of lard by the addition of less than 1 per cent. of hydrogen to the oil, which reaction is brought about by means of a catalizer, such as nickel oxide deposited on kieselguhr as a carrier. In

<sup>4</sup> Poulson: Trans. Internat. Assn. Test Materials, 1912, et seq.

<sup>5</sup> Zeit. für Hygiene, 14,299 (1893).

this case the large area of the carrier adds considerably to the activity of the catalizer and also aids in the filtration and removal of suspended matter from the oil after the reaction is completed.<sup>6</sup>

### 3. FINE STATE OF DIVISION

The natural fineness and uniformity of the particles which go to make up kieselguhr and the ease with which it can be reduced without destroying the cell structure make it useful for many purposes, among which are: Polishing and dusting powders and in many industrial and pharmaceutical lines.

### 4 AND 5. SHARPNESS AND WEAKNESS OF CELLS

The angular nature of the flinty skeletons of the diatoms give kieselguhr an abrasive power which is taken advantage of in the finer grades of polishing and cleaning materials, where a mild abrasive is required. The fineness, together with the angularity, weakness and low compressive strength of the diatoms produce a material which is unsurpassed for polishing and burnishing objects without danger of scratching the surface of the softest metal.

It has been used extensively for metal polish, soaps and for polishing metallic specimens for microscopic examination, dental powders, etc. The above properties are also taken advantage of in producing friction surfaces in the manufacture of safety match surfaces, match heads and similar lines.

### b. REFRACTORY NATURE

As the diatom consist chiefly of silica, a material which is in itself of a refractory nature,<sup>7</sup> this valuable characteristic as a whole is imparted to kieselguhr. The melting point of natural powdered kieselguhr has been reported by the Bureau of Standards to be 1610 deg. C. (2930 deg. F.), and that of a lightweight diatomaceous shale 1,750 deg. C. (3,182 deg. F.), indicating its highly refractory nature. This feature, together with its low thermal conductivity, opens up a wide field for its use in the ceramic industries for the production of lightweight brick and tile for insulating and refractory purposes. Owing to the low apparent density of the pulverized kieselguhr it has found extensive application for fire protection in buildings as a light fireproof wall filler. On account of its smothering effect caused by the exclusion of oxygen from the vicinity of the flame, it is also used as a fireproofing and insulating material in safes, ovens, fireless cookers, electric fuse protectors, etc.

### c. COLLOIDAL CONDITION

The bleaching and decolorizing properties of certain clays, notably in the case of Fuller's Earth, has long been known to be due to the presence of colloidal matter.<sup>8</sup> Recent work on kieselguhr has shown that it carries a large amount of colloidal material, as is indicated by its absorption of certain basic dyes. In certain cases this absorption has been found to be as much as 20 per cent. higher than in the case of a high-grade Fuller's Earth, making it of particular value in the treatment and filtration of a number of materials which were formerly carried out only with great difficulty.

### d. WHITE COLOR

The white color of kieselguhr naturally depends upon the small amount of impurities in the material and upon the freedom from deleterious sediments which settle along with the diatoms in many deposits. When of a

high degree of purity the pure white color imparts valuable properties to kieselguhr in pharmaceutical applications being used in the preparation of many drugs and dentifrices in which the essential qualities are purity.

## II. Chemical Properties

### e. INORGANIC OR SILICEOUS COMPOSITION

As has been shown above, the chief constituent of diatomaceous remains is silica, which, under certain conditions, is found in a high degree of purity in a form which is readily available, thus forming an ideal source of pure silica for a variety of purposes. It has been used as an ingredient in the compounding of glazes, fluxes and bodies of a siliceous nature. The specific heat of kieselguhr has been determined by Becker to be 0.2089.<sup>9</sup>

### f. SOLUBILITY IN ALKALIES

One characteristic of the silica contained in kieselguhr is the ease with which it reacts and combines with alkalies and alkaline salts, making it a convenient form of silica for the manufacture of silicate of soda or water glass, ultramarine and other siliceous products.

### g. INSOLUBILITY IN ACID OR NEUTRAL SOLUTION

Kieselguhr is not affected by the action of acids (except hydrofluoric) or neutral solutions, which feature makes it suitable for the filtration, absorption or transportation of these bodies without contaminating them.

### Testing Kieselguhr

In industrial work it is essential in order to obtain the best results that the kieselguhr which is best adapted to the particular requirements be used. In order that this may properly be determined, it is advisable to apply certain chemical, physical and mechanical tests, which will be outlined. While it is unnecessary in a great many cases to carry out all of these tests in detail, it will be found that they give the general character and adaptability of the material for the purposes intended. For instance, for filtration of materials, the apparent density, fineness and behavior of the kieselguhr in solution will enable a far better valuation of the material to be made than chemical analysis. For ceramic purposes the analysis showing the amount and nature of the fluxes present would be of the greatest importance. In short, the testing of this material should be carried out with an idea of determining the physical properties which have the greatest bearing on the manner in which the material is to be used.

**Sampling.**—On account of the relatively small percentage of material other than amorphous silica present in kieselguhr, and the large surface and porous nature of the material, it is essential that the sampling be done with great care in order that a representative sample may be obtained. For accurate work it is advisable that all samples be weighed out at the same time and the percentage of moisture determined in one of them, and also that the weighing be carried out as rapidly as possible on account of the change in weight due to the loss or absorption of moisture.

**Color.**—The color of kieselguhr as it is received should be determined on a sample of approximately 150 mesh, both dry and moistened with water. Some information can also be obtained by comparing the original color of kieselguhr with that of ignited kieselguhr which has been heated above 1,000 deg. C. under oxidizing conditions. The color of the last-mentioned sample will be of value in determining the approximate percentage of iron oxide in the material and may be made upon the sample from the "Loss on Ignition," as will be outlined in the analysis of kieselguhr.

<sup>6</sup> C. Ellis: Hydrogenation of oils, J. I. & E. C., 5, 2, 95.

<sup>7</sup> Knott: Technologic Paper 10 of the Bureau of Standards reports pure silica flows distinctly at 1750° C.

<sup>8</sup> Parsons: Fuller's Earth: Bureau of Mines Bulletin.

<sup>9</sup> Johresber: Chem. Tech. (1876), c. 22, p. 481.



**Apparent Density.**—In the case of pulverized kieselguhr a tared vessel is filled loosely with the material and the excess scraped off of the top by means of a straight-edge. The weight of kieselguhr divided by the weight of an equal volume of water gives the apparent density. In the case of blocks or bricks made of kieselguhr, this value is obtained readily by measuring and weighing the sample.

The apparent density is one of the most valuable and most readily determined of the physical properties of kieselguhr, and forms an excellent criterion for the approximate comparative efficiency of the product for many purposes.

**Fineness of Grain.**—A weighed sample is washed through the proper size screen with a fine jet of water, and the residue dried, weighed and the result expressed in percentage loss through the various sizes.

**Character of Grain.**—The shape and general character of the kieselguhr cells and the approximate amount of inactive or non-cellular material present may be readily determined by means of the microscope. The source of the material may often be determined by a microscopical examination.

**Absorption.**—A dried five-gram sample of kieselguhr is allowed to absorb a measured quantity of water from a burette until continued stirring fails to produce a pulverulent mass. The absorption coefficient is expressed in terms of cubic centimeters of water absorbed per gram of dried sample. The stirring should be done in a manner least destructive to the frail cells, grinding and crushing being avoided.

**Chemical Analysis.**—One-half gram sample is weighed in a platinum crucible, heated to redness to drive off organic matter, cooled, moistened with small amount of distilled water, about four drops of dilute sulphuric acid and one cubic centimeter of hydrofluoric acid added. Heat on a sand bath to fumes, and repeat the operation until decomposition is complete, after which the crucible is ignited strongly until constant in weight. The loss consists of moisture, organic matter, combined water and silica. Of these the moisture is determined on a separate sample at 105 deg. C. and the organic matter and combined water are determined on the same sample as "Loss on Ignition" by continued strong heating until constant weight is obtained. These values are then deducted from the complete loss, giving the silica content of the sample. The residue from the hydrofluoric acid treatment is fused with sodium potassium carbonates, dissolved in diluted hydrochloric acid, oxidized with bromine water and the hydroxides precipitated by means of ammonia which are filtered off, ignited and weighed. In the precipitate the iron, alumina and titanium oxides are determined by any of the well-known methods and the lime and magnesia determined in the filtrate.

#### Kieselguhr Products

In selecting the most suitable kieselguhr product for use it is quite often possible that a number of the properties desired can be obtained from several of the products, and particular care should be taken to select the one which has the greatest applicability to the problem in hand.

**Natural Kieselguhr Blocks.**—Sawed natural kieselguhr blocks, when dry, are light, weighing approximately twenty-eight to thirty-five pounds per cubic foot. They are fairly strong, having a crushing strength of 400 pounds per square inch, and have an exceptionally high insulating value, as shown in Table I. Their melting point is 1,610 deg. C. (2,930 deg. F.), and are unaffected up to temperatures of a red heat, except for slight shrinkage. They can be sawed to almost any size or shape, and offer an ideal and highly efficient material

for insulation of moderately heated bodies and for cold storage work. For very high temperatures, however, they have the disadvantage of shrinking and spalling.

**Pulverized Kieselguhr.**—The natural kieselguhr when reduced in a manner which does not destroy the structure of the diatoms is ordinarily supplied in many grades of fineness and weight suitable for any of the uses to which this material may be applied. The weight per cubic foot varies between eight and twelve pounds, according to the grade and state of division. The color of the various grades runs from pure white to light brown, depending on the percentage of impurities present. The silica content ordinarily runs from 80 to 90 per cent. on the dry sample. The material has a very high thermal and sound insulating value, and is used as a filler for a variety of purposes, as indicated above.

**Lightweight Kieselguhr Insulating Brick.**—When pulverized kieselguhr is treated and burned under proper conditions a lightweight brick is produced which has a very high insulating value, which is fairly refractory, and sufficiently strong to withstand considerable handling and transportation. In preparing this brick it is essential that the kieselguhr be treated in such a way as to retain its natural insulating properties as far as possible. It contains approximately 95 per cent. silica, has an apparent density of 0.70 or less and an approximate weight of 45 lbs. per cubic foot. A regular size building brick weighs approximately  $1\frac{3}{4}$  to 2 lbs. While this brick is not adapted to highly refractory use on account of its shrinkage at high temperature, it can be used for insulating purposes up to a red heat without damage. On account of the fine grained texture of this brick, however, it is advisable to protect it from extremely sudden changes in temperatures. The compressive strength of this brick is about 500 lbs. per square inch. It is used principally as an insulating backing for more refractory brick.

**Kieselguhr Firebrick.**—Firebrick made of kieselguhr flint are acid, highly refractory brick of a much higher insulating property than any firebrick now on the market. They are used for building and lining high-temperature furnaces, kilns, boiler setting and general metallurgical work where a lightweight non-conducting, refractory brick is required. The apparent density of this brick is approximately 1.00; a standard size firebrick weighing about 3 to  $3\frac{1}{2}$  lbs. The Bureau of Standards reports the melting point of this firebrick to be 1,650 deg. C. (3,002 deg. F.). The thermal conductivity has been found to be in accordance with the table given above. The crushing strength of this brick is approximately 1,200 lbs. per square inch.

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#### Manganese Bronze

BY W. M. CORSE AND V. SKILLMAN

Prior to the final quarter of the last century it was well known that the addition of small amounts of iron to copper and its alloys had a decided hardening and strengthening effect. Its introduction resulted at the same time in producing some less desirable qualities, as, for instance, a decreased ductility.

In the constant search for something better, the introduction of manganese in place of iron was tried. Cupromanganese was prepared by reducing pyrolusite or a purer form of manganese dioxide in the presence of copper. This alloy was then employed to introduce small amounts of manganese into brasses and bronzes. Some benefit resulted and the manganese brasses and bronzes met with favor for some time. The manganese acted as a deoxidizing agent, much as the later perfected intro-

duction of phosphorus in bronzes does. There do not seem to be on record the results of any experiments which would give the comparative value of iron and manganese when introduced separately into brasses and bronzes.

It remained for P. M. Parsons, of London, England, to add both iron and manganese. As a result he was granted British Patent 482, February 7, 1876, for his invention. A sentence from the patent reads: "Alloys of copper and tin or zinc, or both, may be rendered more homogeneous, closer in texture, harder and stronger by adding thereto a proportion of ferro-manganese, spiegeleisen, or other carburet of iron containing manganese." It should be noted that his patent was simply for the introduction of iron and manganese into alloys of copper and tin or zinc, or both. No mention was made of any particular alloy at all similar to the special brass which is now quite universally termed manganese bronze. The addition of iron and manganese to a metal containing 90% of copper and 10% of tin (gun metal) which is a true bronze was mentioned.

In the United States a patent No. 206604, 1878, which was a duplicate of the British patent, was granted to Mr. Parsons. These patent rights were controlled by the Manganese Brass & Bronze Company, Ltd., of London, England. They proceeded to manufacture several different metals containing iron and manganese as specified. The alloys ranged from those containing zinc much in excess of tin to others composed of practically copper and tin alone.

It was soon discovered that the manganese brasses or high zinc alloys were entirely unsuited for sand castings and could only be employed successfully for casting in metal molds. It was not long before they were discarded almost completely in favor of the manganese bronze, composed of copper, tin and manganese, which gained some popularity. The first castings, therefore, of propellers and the like, which were described as being made of manganese bronze, were cast from true copper-tin bronzes.

These bronzes were not subject to the same casting limitations as the brasses. They could be readily handled in sand, but on account of the greater cost of tin as compared with zinc they were more expensive than the brasses. The latter in the form of forgings, rods, wire, etc., had been shown to possess such desirable properties in regard to strength, ductility and the like that there seemed to be little doubt of their value in the form of castings if such could be successfully made in sand. This was later made possible by adding a small amount of aluminum to the manganese brass, and here begins the history of the now well known, but wrongly named, manganese bronze casting.

In 1888 Mr. Parsons was granted a second British patent (No. 11512, August 9, 1888) covering the addition of aluminum to the class of alloys mentioned in his previous patent. For some reason he seems to have failed to take out a duplicate United States patent for this. United States Patent No. 415832 was granted to A. H. Cowles, however, for the same idea.

With this knowledge at hand it was now possible to make sand castings from a cheap brass containing as much as 40 to 45% zinc, which would have physical properties equal, or even superior, to castings made from the more costly bronze. Probably on account of the bronze-like properties of the newly discovered brass, a confusion in names resulted and until comparatively recent times, manganese bronze was used to describe both the tin and zinc alloys of the type under consideration. This also accounts for the great discrepancy for a time in statements regarding the physical properties of manganese bronze.

While progress was being made in Europe in the incorporation of iron and manganese in brasses and bronzes, the metallurgists of this country were not dormant. The effect of ferro-cyanide, ferro-manganese, manganese oxide and the like was being studied. A brass called "Vesuvius Metal," which contained both iron and manganese had been developed. It contained no aluminium and was found to be unsuited for sand casting. Shortly after, another brass called "Tubal Bronze" was evolved which was followed by Consol Metal and numerous other brasses of the same general character.

About 1893 the Manganese Bronze and Brass Company, holders of Parson's patent rights, licensed the rights for making Parson's manganese bronze in the United States. Since then many companies have undertaken the manufacture of this important alloy. There need now be very little uncertainty as to what is meant by manganese bronze. Practically all the best brands upon the market at the present time fall approximately within the chemical specification adopted by the American Society for Testing Materials which calls for an alloy containing 55 to 60% copper and 40 to 45% zinc with small amounts of iron, tin, manganese, aluminium, etc.

It will be noted that the alloy now recognized as a manganese bronze is in reality nothing more than a special high-zinc brass. The presence, however, of the metals other than copper and zinc is what places this highly valuable alloy in a class quite by itself. At the present time it is the principal non-ferrous alloy employed in the form of castings to any extent, as a substitute for steel. Its valuable physical properties are quite dependent upon the proper proportioning and alloying of the elements present in small amounts.

Commercially, there are two grades of manganese bronze now manufactured. One which is used for rolling and drawing is very similar to the old manganese brass and contains no aluminium. Its copper content is also slightly higher than the other grade which is used for sand castings. The latter contains aluminium. They are both manufactured in about the same way and a description of the method used in making material for sand castings would explain the process.

The first step in the manufacture is the preparation of the hardening or "steel alloy." This is composed of the iron, manganese, and tin which is to go into the mixture. Ferro-manganese is usually employed and the additional iron necessary is introduced in the form of wrought iron. Straits, or some other good grade of tin should be used.

The formula mostly followed is, approximately,

80% Ferro-manganese.....	56.3%
Wrought iron .....	12.5%
Tin .....	31.2%

By introducing the tin into this alloy the melting point is so much lowered that the otherwise difficultly melted ingredients are readily dissolved in the copper when the final bronze is made.

After a stock of hardener has been prepared the alloying of the bronze is proceeded with. The mixture commonly employed is as follows:

Copper ingot .....	55.0%
Zinc .....	42.0%
Hardener .....	2.5%
Aluminium .....	0.5%

A portion of the copper is melted and after being brought to a good heat the hardening alloy is added. This must be thoroughly stirred in and heating continued until it is entirely melted and alloyed. The aluminium is then added which causes a further increase in temperature, which insures the melting of the last traces



of hardener. The remainder of the copper is then added and allowed to melt, after which the zinc is added. A good grade of zinc is necessary, as the lead present as an impurity in the poorer grades is very detrimental in the finished bronze. The whole is then thoroughly stirred, brought to the proper temperature and poured.

It is usual practice to cast the newly formed alloy into ingots and to remelt them to make castings.

If the preceding formulæ are followed a bronze should be produced which would fall within the specifications issued by the United States Navy Department, January 20, 1912, and which call for manganese bronze containing

Copper, 56 to 58 per cent.

Zinc, 40 to 42 per cent.

Tin, not to exceed 1 per cent.

Aluminium, not to exceed 0.5 per cent.

Lead, not to exceed 0.10 per cent.

Manganese, not to exceed 0.3 per cent.

As regards the physical properties of the above alloy, a test specimen properly cast in sand should give well over 70,000 pounds ultimate tensile strength per square inch, and at least 20% elongation in two inches. Some specifications also call for a minimum elastic limit per square inch, and a minimum reduction of area. The values given for these have been shown to depend to such an extent upon the "personal equation" of the operator conducting the test and upon the apparatus with which he is working that it would appear preferable to leave them out of future specifications.

Bronzes of various strengths and ductility can be produced by varying the percentages of copper and zinc and of hardener used in making the alloy. If more elongation is desired, less of the hardening alloy is added. A greater quantity of the latter would produce a stronger and harder alloy, but one with less reduction of area and elongation.

The percentage of the ingredients used in making the hardening alloy may also be varied slightly, as each plays a particular part. The iron, which is most important, increases the strength and raises the yield point of the bronze. The tin also increases the strength, but if present in more than a certain amount, also causes brittleness. The manganese acts as a deoxidizer and is considered by some as a carrier of the iron. Its presence causes the iron to alloy more easily at least. If sufficiently large amounts are added it has a strengthening and hardening effect similar to iron, but not as pronounced.

In making castings from manganese bronze when the alloy has been successfully prepared, the goal is still only partly won. It is generally conceded by founders that this alloy is one of the most difficult of the non-ferrous mixtures for the uninitiated to properly handle. The metal may be quite ruined by allowing it to remain in the furnace and overheat after it has been properly made. As a result of the high zinc content, its melting point is comparatively low, lying between 1400° and 1500° F., and therefore overheating or "burning" easily happens.

Chemical control is a necessity in handling this alloy if rigid specifications are to be continuously met.

The approximate production in the United States of this alloy is 1500 tons annually.

Buffalo, N. Y.

**Tin in the form of cassiterite** is found with gold in the gravel on Sullivan Creek, near Rampart, Alaska. In the richest spots the gravel will yield as much as half a pound of tin to the pan. This is equivalent to a value of about \$18 per yard. Stream tin is worked in the York district where the gravel has a value of only \$9 per yard.

## Federal-State Controversy Over Radium-Bearing Lands in Colorado and Utah

[Editorial Correspondence]

Interest in radium-bearing minerals in the United States has grown rapidly in the last year. Twelve months ago radium was considered largely of academic importance, but to-day the potential value of a genuine radium industry in this country is recognized, not only by those whose foresight has given the matter its present prominence, but also by technical men whose interests have been centered in other branches of mining and metallurgy. Federal and state officials are concerned as to the disposition of land containing radium-bearing minerals, and a strong sentiment is developing in favor of some means of securing for our country an adequate supply of radium from our own ores.

Colorado and Utah are the states most concerned. The deposits of radium-bearing minerals in these states have received careful attention from the Bureau of Mines, which has given welcome publicity to the whole matter of uranium, radium and vanadium in a preliminary report recently issued as *Bulletin 70*.<sup>1</sup> "The United States possesses unique deposits in these (Colorado and Utah) carnotite ores. They constitute at present the largest known supply of radium-bearing minerals in the world. With the exception of the ore mined and utilized by two firms, practically every pound is shipped abroad. Up to the present very little interest has been shown by Americans in these deposits, which may not be duplicated as to quantity in any part of the world. The only other large deposits of uranium-bearing ores known are those of Austria. They are considered of such importance that the Austrian government has taken entire charge of them. The output from the carnotite fields of this country is much larger than that from the Austrian mines and is likely to continue larger for some time to come, but the ore should be mined with minimum waste, and the industry should yield a maximum profit to this country."

In the light of these facts it is not surprising that our deposits have attracted the attention of European buyers, and that scientists and government officials in this country should become interested in exploiting them in such a way as to produce first an adequate supply of radium for domestic use, without undue prejudice to the needs of foreign countries. The private organization of the National Radium Institute in this country was a step in that direction.

### The Controversy

A proposal on the part of the government to withdraw the Colorado-Utah carnotite deposits from private entry has precipitated a storm of criticism, particularly in Denver, against a further exercise of federal conservation of the states' resources. Colorado's commissioner of mines has been particularly active in creating a sentiment of opposition to such an action. It is argued that federal interference at this time, when the mining and treatment of carnotite promises to become an important item in the state's mineral industry, would be most unfortunate; that it will retard the development of the state; deter further prospecting; limit the employment of miners and freighters, and generally act as a bar to progress.

Another argument by the state is that the greater portion of the carnotite produced is now used by domestic companies, and that a needless cry is being raised against exportation of ore to foreign countries.

<sup>1</sup> Further reference to production and exportation appeared in this journal December, 1913, pp. 673-4.

The "foreign invasion" is regarded as a myth and dismissed as a fancy of ultra-conservationists. A further point raised is this: If the government withdraws radium-bearing land from entry what is to prevent an extension of that policy to mineral land containing gold, silver, lead, zinc and copper.

It is plainly the fear of the state authorities that an act of withdrawal will result in unnecessary delay in the final disposition of the lands, and that a condition will be created similar to that which has existed in Alaskan and Western coal lands. There is also a feeling that more rapid development will take place under conditions of free prospecting by individuals than under government supervision and control. In short, the attitude of the state in this question is but an instance of the general opposition in the West to federal conservation as exemplified in some previous cases.

#### What the Government Proposes to Do

The other side of the question has not been as thoroughly ventilated, and much of the state's criticism has been made without a knowledge of the details of the government's true proposal. The withdrawal of the land in question has been considered for some time, but the proposed method of doing it has only recently been announced. Strong opposition developed, even among federal officials, against the usual procedure of withdrawal under the Land Office regulations; for while the act of withdrawal would be a simple matter and quickly done, the more important matter of immediate exploitation of the deposits would not be so easily accomplished. The production of radium was recognized as being of prime importance, not only to the states containing the mineral deposits, but also to the entire country.

The plan finally proposed can be given best in the words of the Secretary of the Interior, in a letter to Congressman Foster, chairman of the House committee on mining: "The Secretary of the Interior should be authorized (by Congress) to conduct explorations and researches with a view to determining the practicability of developing from such ores (carnotite) a supply of radium, and also authorized by lease or otherwise to provide for the mining and treatment of radium-bearing ores in such manner as would best secure a supply of radium for the use of the government of the United States and the hospitals of the country."

An analysis of this statement will reveal intentions quite different to those assumed by western mining men. The significant parts of the statement are that the Secretary seeks authority "to conduct explorations and researches," and to "lease or otherwise provide for the mining and treatment of radium-bearing ores." The mere withdrawal of land from entry, without automatically providing for mining and treatment of ore, would be intolerable; and any resolutions on this subject passed by Congress should carry adequate and proper provision for exploration, mining and treatment, either by lease to private parties or through governmental agency, probably the Bureau of Mines.

There are arguments on this side of the question, as on the other. Those who favor the proposed federal plan contend (1) that the states (Colorado and Utah) will benefit by the activity of the government; (2) that no present owners or operators of radium-bearing land will be injured; (3) that the production of radium is such a marked exception in the mineral industry as to be entitled to special consideration from the government; (4) that more active and intelligent prospecting will be done under government supervision; and (5) that an adequate supply of radium for this country can be obtained most quickly and cheaply through governmental agencies.

Practically the only persons who can be injured

under this plan are future prospectors, but even they can profit by making special effort to locate claims pending final action by the government. Up to date comparatively little prospecting has been done on personal account. Most of the work has been done by paid agents of the large companies, and even this has been confined to locating claims on which outcrops were plainly visible. Such deposits are now privately owned and the ores can be sold when and where the owners wish. Prospecting and exploration on a systematic basis might develop further deposits; but in view of the physical difficulties attending such work in those parts of Colorado and Utah containing the carnotite deposits, few individuals have undertaken to prospect; but even they could not do the work on a scale anticipated by the government.

Undoubtedly great pressure has been brought to bear on the government, through medical societies and other agencies, not so much to prevent the exportation of radium ore from this country, as to produce as soon as possible an adequate supply for domestic use. A great deal of such ore is going abroad, and one unfortunate feature of this is that American users can buy but little of the radium produced from their own ores, even at the rapidly rising speculative prices. The government stands for the local production of radium, possibly at Denver or some suitable western city, for the purpose of supplying the material at a price fairly commensurate with the cost of production. This would eliminate the speculative feature of present prices which have practically doubled in the last year. The government would be able to control only such new deposits as it might purchase or discover by exploration, and only such ore as it could buy from present claim owners. There would still be a comparatively large quantity available for purchase by foreign concerns.

#### A Case for Cooperation

No ultimate good can come of a prolonged fight over this question. It is a time for cooperation of the different interests. All of the facts should be considered on their genuine merits, to the end that this country may take advantage of what appears to be a wonderful opportunity. The West will profit in any event; but the circumstances of the case are such that it should profit in a way that will be a credit to the whole country. If a fight is precipitated in Congress it might result in a mere withdrawal of the land without financial provision for exploiting it, which would be a most unfortunate outcome. If the states should wage an unsuccessful fight on the matter of withdrawal, they would then be in a poor position to influence congressional appropriation for mining and treatment.

The daily press has been filled with a lot of senseless twaddle and half-truths on this subject, some of which is plainly inspired by personal interests or born of political necessity. It serves no useful purpose, but tends to create false impressions. No satisfactory settlement of the proposed conservation can be reached without a knowledge of the whole truth.

The type of conservation which has found acceptance in this country is that which utilizes our resources to meet present needs without undue waste. Perhaps the matter of producing radium is a case in point. The element already has proved a wonderful therapeutic agent. The demand exceeds the supply. We have the raw material and we ought to make the best use of it now. Hence the legitimate opposition to a withdrawal of the land containing it, without automatically providing means for proper exploration and the ultimate production of radium for domestic use.



## Handling the Raw Materials at the Iron Blast Furnace

BY J. E. JOHNSON, JR.

(Concluded from January issue, page 53)

### Design of Bins

We can now turn to the bins which serve for storage of the raw materials going immediately into consumption.

These bins are of many types, bins having had a development covering many decades. Substantial and well designed wooden bins were in use at a few plants thirty, forty and fifty years ago. But the great storage required for modern plants necessitated one and frequently three or four tracks on top of the bins, all of which must carry the most heavily loaded railroad equip-

The design of gates for bins is a matter the difficulty of which in practice is as great as its simplicity appears to be on cursory examination. The material to be handled is irregular in size, irregular in shape, rough, as likely as not to be sticky, and more likely than not to have its coefficient of friction greatly altered by a change from dry to wet. If the gate opens and closes from above, guillotine fashion, it may just happen to catch the largest lump passing, which may be too strong to be crushed, and holding the gate open will leave room for a rapid flow of finer material under it. If the shape of the chute be not right the material will jam and bridges exercising apparently almost human, not to say devilish ingenuity, in building an arch which quickly cuts off the flow of material from the bin, and which cannot be broken outward because the material is under compression, nor inward except with the greatest

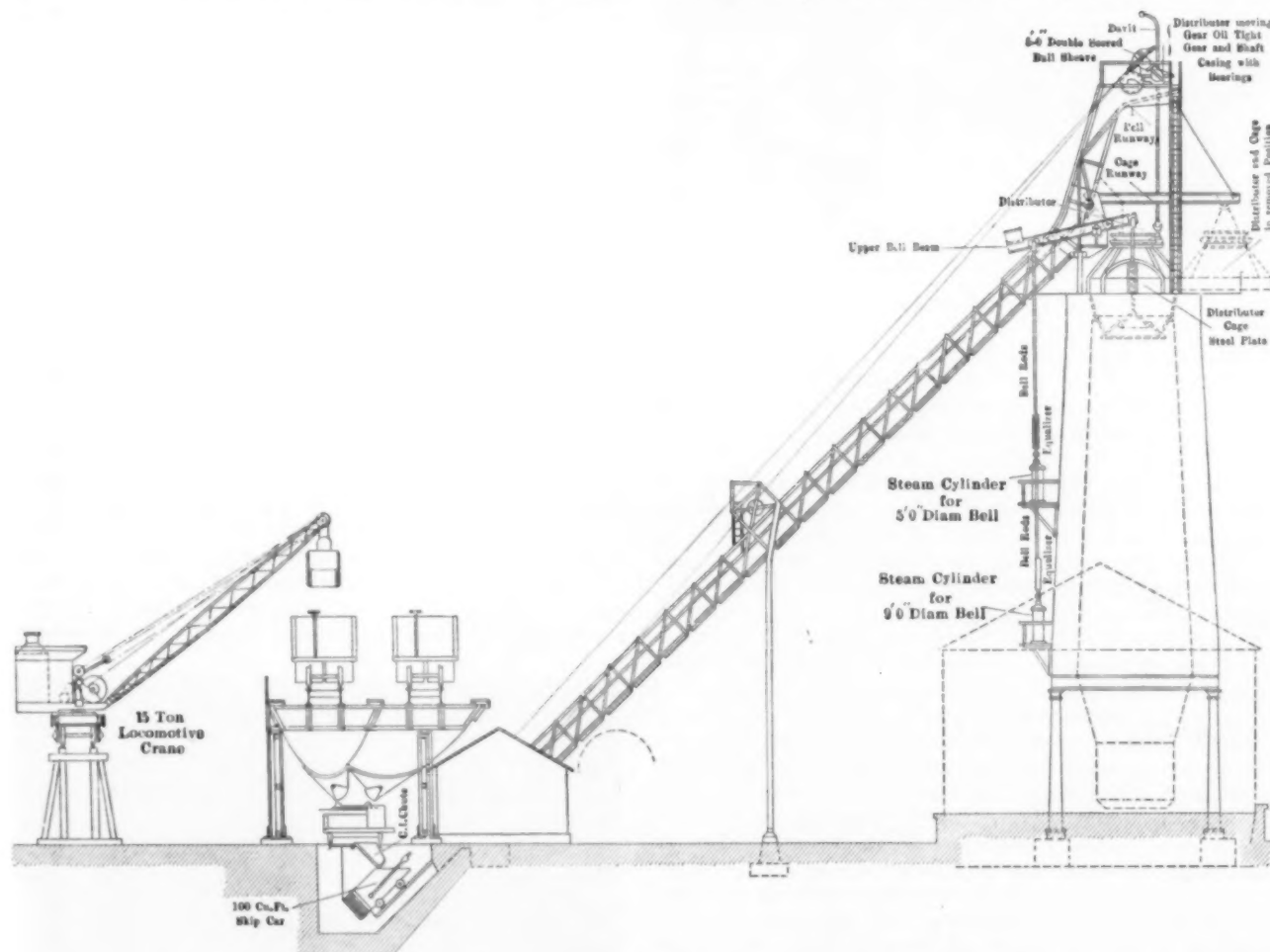


FIG. 16—FURNACE WITH BROWN SKIP HOIST AND PARABOLIC BINS

ment. This, with the excessive maintenance of wooden structures, has gradually forced the introduction of steel bins, built as an integral part of the structure which supports them and the railroad tracks at the same time. Recently concrete bins also have been used.

It is useless to try to illustrate all the types of bins which have been used, and I shall therefore show only three of the best known types, which are brought out by the three concerns whose ore-handling machinery has previously been described.

It is necessary to explain that at the large modern plants where equipment of the highest type is used, mechanical filling is now practically universal, and these bins are not therefore designed to discharge into filling barrows, but into the modern successor of the filling barrows, the scale car.

difficulty because the pressure of all the material in the bin lies against it.

More than one case is on record where an engineer or furnace manager has designed a new type of gate for a bin, taken a guest out to see how beautifully it operates, and then had it fail so completely that the filling barrow, or even the scale car, would be buried up because the material could not be shut off when the "improved" gate was brought into play.

Even if these fundamental difficulties be overcome great care is necessary in placing the spouts on the bins and bringing them sufficiently close together so that material does not build on the space between them and in time almost fill up the bin. This may seem like an extreme statement, but I have seen bins of the very best construction and most carefully designed, which

looked to be full of ore, but on a closer examination two holes, three or four feet in diameter, were to be seen running down from the top to the two chutes below. These holes would represent almost the only free-flowing capacity of the bin. The ore being plastic and sticky, had built up upon the base of the bin and the bridge between the spouts, until the capacity of the bin was almost gone. This is likely to happen to some

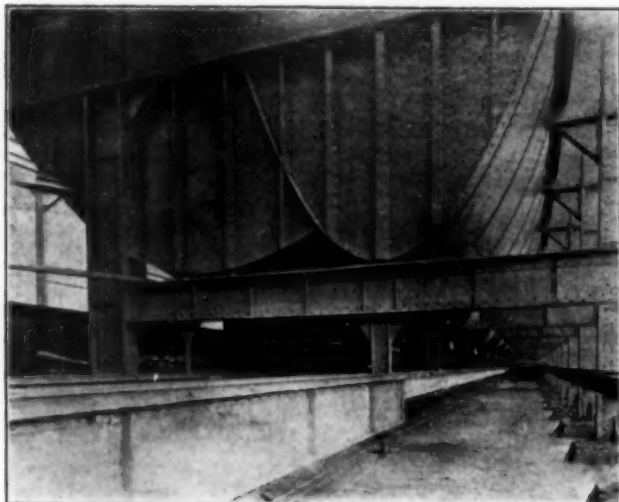


FIG. 17—PARABOLIC BINS

extent with any design, and the only way to meet the situation is to dig the bin out at frequent intervals, as the rapidity with which the ore builds is increased as it gets a larger and larger foothold.

It was with the object of overcoming these various difficulties and furnishing bins whose flow would be under the absolute control of the operator that the three designs now to be described were brought out.

Taking the designs of the three builders mentioned in the same order as before, Fig. 16 shows a "parabolic" bin designed by the late Alexander E. Brown, of which the principle is taken from the fact that when a liquid or semi-liquid is suspended in a trough of flexible material, the cross section assumed by the trough is a parabola, therefore by giving the bin this shape, stresses tending to deform it are eliminated, and only its weight needs to be considered. These bins are suspended from heavy girders, which in turn are supported by steel columns. The complete parabola at the left is for ore. The incomplete one of greater width, on the right, joined to the ore bin at the left, is for coke.

The spouts on these bins with their gates in the form of cylindrical quadrants are plainly shown at the bottom, as is also the scale car beneath them. A locomotive crane standing on an adjacent trestle, and in a position to discharge ore into the railroad car standing on the bin trestle, is also clearly shown.

The construction of the bins is well shown by the photograph (Fig. 17).

Fig. 18 shows the bottom of the bins with their chutes, also the scale car and its operator. It will be seen that the quadrant gates are operated by a pair of connecting rods attached to crank pins, carried on a heavy gear shaft, supported at the top of the chute. The large gear is driven by a pinion which in turn is driven by a pair of beveled gears. From the vertical shaft of the driver of these depends a shaft carried by a universal joint and carrying a socket at its lower end. The scale car carries a square-headed shaft, which can be thrown up by the operator to engage with the socket for any chute. After this is done a small motor is started and the gears revolved until the crank pins

come to the bottom position, at which time the gate is wide open. When the required amount of stock has been drawn the gate is raised by revolving the large gear shaft through another half revolution.

The style of bin and chute designed by Hoover & Mason is shown in Fig. 19. No attempt is made in this bin to use the parabolic shape, which is open to the objection that its angle changes, so that while it may be steeper than necessary in some portions it is flatter than necessary in others, and the latter condition prevails near the bottom, where the flow should take place most freely.

The bottom of the bin is formed by a horizontal roller five feet in diameter which lies close to the bottom edge of the chute, so that no material can get between the two. This can be rotated at the will of the operator in the direction shown by the arrow. The angle from the top of the chute opening in the bin to the top of the roller is considerably less than the angle of repose of the material, so that no material can possibly get out of the bin when the roller is stationary. On the other hand, when it is rotated the material is carried forward by the roller to a point at which its slope is greater than the angle of repose of the material, which then slides off. When the roller is stopped the flow of material instantly ceases.

The front of the bin is built with louvre with a reverse slope, through which it is impossible for the material to make its way out, but through which it is very easy for the operator to thrust in a bar and break any bridge or arch that may form to obstruct the flow.

The roller is driven by means of gearing thrown in by a clutch worked by the operator. The gearing is actuated by a line shaft or driving shaft, which runs continuously. There is a separate roller for each discharge, the equivalent of each chute in the older type of construction, and the design is such that the ends of these rollers come very close together, leaving a minimum of space between them, so that the bin is practically open at the bottom all the way along. This to a great extent prevents the formation of accumulations of ore, as these have no foothold on which to begin to form, the bottom of the bin being kept clean by the continuous

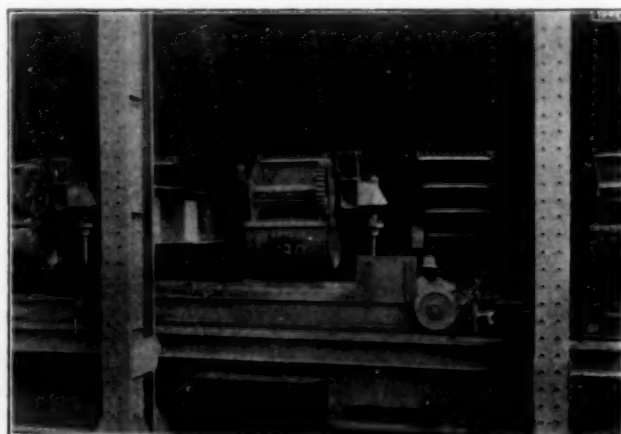


FIG. 18—BOTTOM OF BROWN HOIST BINS WITH THEIR CHUTES, AND SCALE CAR WITH OPERATOR

sliding of the material over it, and no bridges between chutes existing. For the coke bin the roller is perforated, and by an ingenious arrangement made to serve as a screen for the removal of the fine material from the coke. This action is always complete and automatic because the roller cannot run as a feed device without also acting as a screen.

The transfer car used in bringing the ore from the



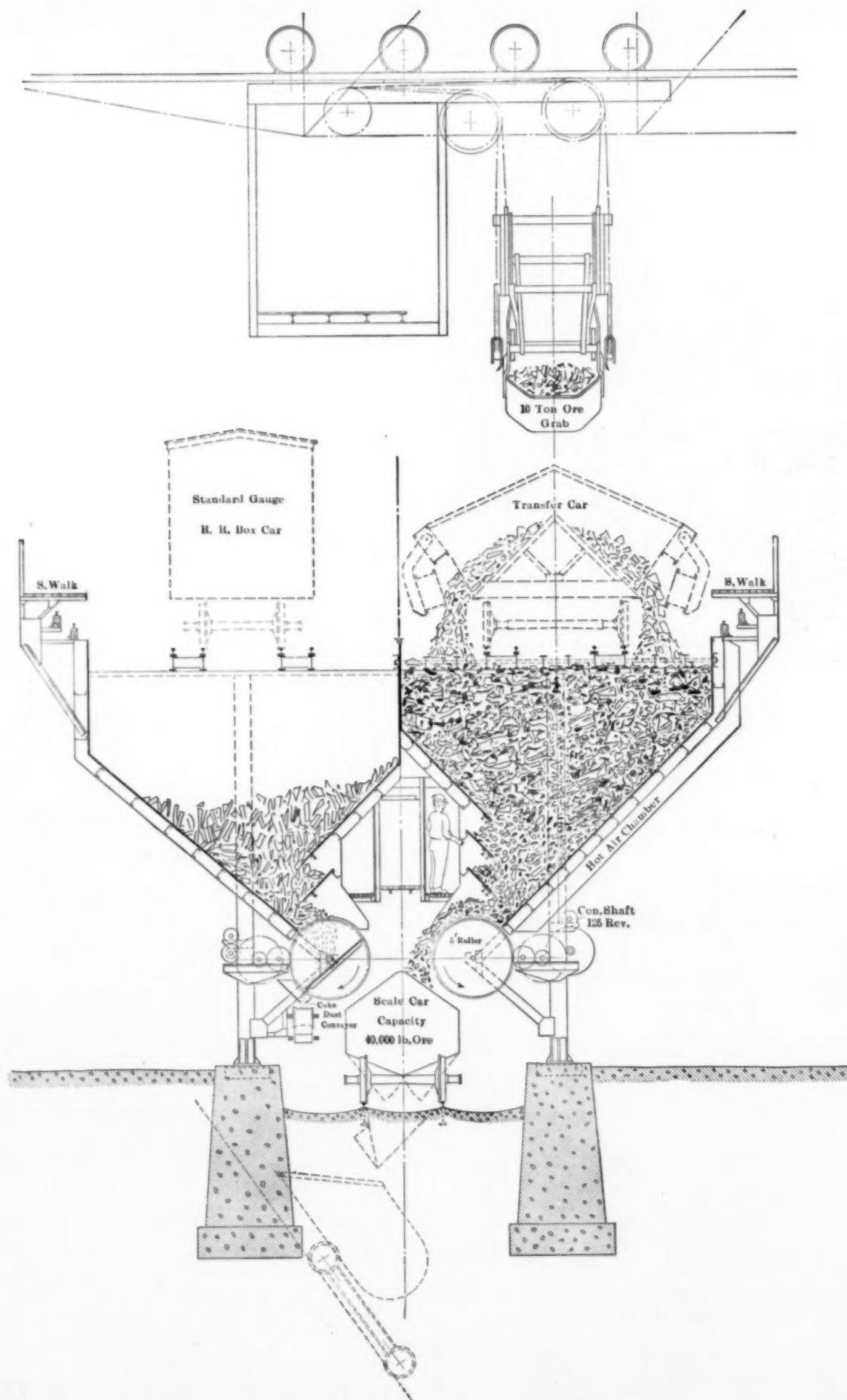


FIG. 19—HOOVER &amp; MASON BIN AND GATE

bridge to the bin is shown in dotted lines above, as is also the overhanging end of the ore bridge with its grab bucket and trolley.

A gate has been introduced by the Wellman-Seaver-Morgan Company, which is on the same principle in all

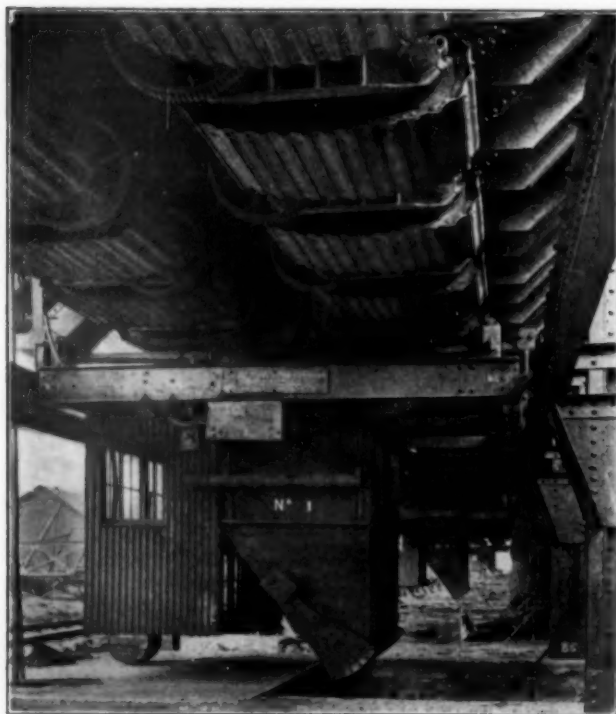


FIG. 20—WELLMAN-SEAVER-MORGAN GATE—ENDLESS BELT MADE OF OVERLAPPING METAL SLATS ON SPROCKET CHAINS

particulars as that of Hoover & Mason except that the former use an endless belt made by overlapping metal slats mounted on sprocket chains, as shown in Fig. 20, instead of a roller. The pressure of the stock on top of this is taken by beams lying inside the endless belt,

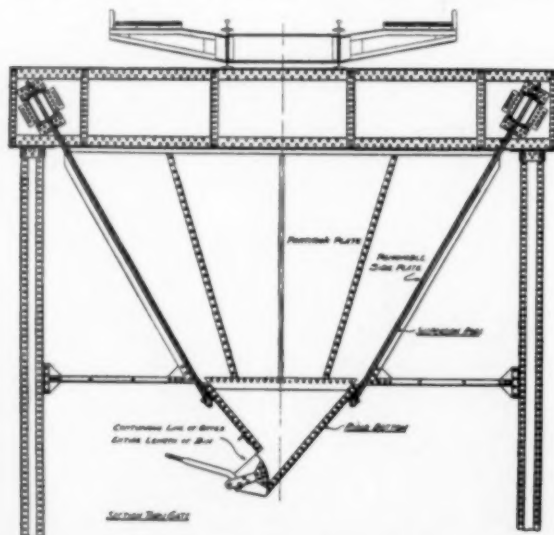


FIG. 21—HEAVY STEEL "BAKER" SUSPENSION BIN WITH HAND-OPERATED QUADRANT GATES

on which the upper half of the belt slides. Owing to the location of this apparatus up underneath the bottom of the bin, the construction is not as clearly shown by the photograph as might be desired, but the overlapping metal slats and the sprocket chains are visible, and

the operation will be understood from the description of the Hoover & Mason apparatus. The metal belt acts as a bottom to the bin and carries the material bodily forward until it drops over the driving-sprocket end into the scale car.

It will be noted that all three of these designs which jointly have probably been applied to a greater tonnage of bin capacity than all other types combined use power for the operation of the gates.

This is because of the difficulty that has often been met in operating hand gates quickly and positively, to which I have already alluded. At the same time it must be understood that many hundreds of bins are in successful use with hand-operated gates, which have the advantage of greater simplicity and lower first cost than any of the power-driven gates.

Fig. 22 shows an outline drawing of the Baker sus-

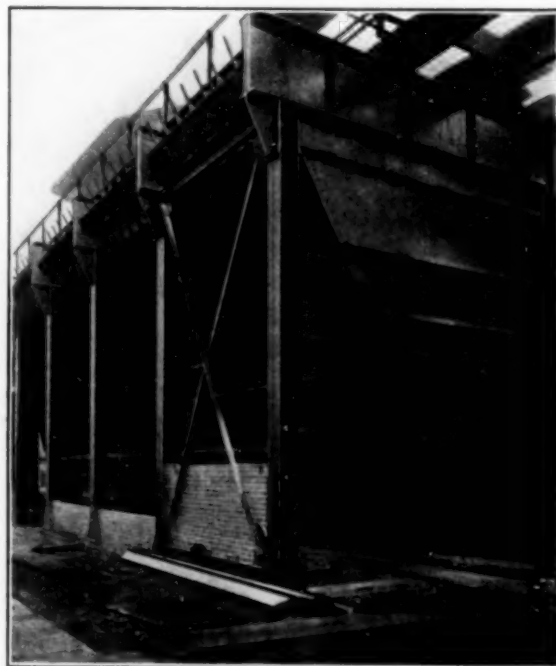


FIG. 22—MC KEE-BAKER SUSPENDED BIN WITH CONTINUOUS LINE OF GATES, HAND OPERATED

pension type of bin built by Arthur G. McKee, Contracting Engineer, Cleveland, Ohio. The gate in this type of bin is a quadrant of a cylinder, but in the reverse position to that used on the Brown bin. The axis of the cylinder is so located that the flow of the material tends to close the gate, so that it is not liable to be opened accidentally. The gate is operated by the scale-car operator through the lever shown in the drawing.

Owing to the absence of machinery these gates are only separated from one another by the small space necessary for clearance, so that the opening in the bottom of the bin is continuous and the formation of bridges and building up of the ore inside the bins is thereby to a great extent prevented.

These bins are, like the Brown, of the suspension type, but instead of their cross section being that of the true parabola it is made up of four tangents thereto, which give to a large extent the same freedom from distortion that comes from the use of a true parabola, any minor stresses of this nature being taken up by the transverse partition plates and the rigid bottom.

A considerable tonnage of these bins is in successful operation at various plants and there are many others with other types of hand-operated gates, many of which are entirely successful.



### Methods of Hoisting in Mechanical Charging

In hoisting for mechanical filling, as apart from distribution (the latter being used in the technical sense of distributing the stock properly in the top of the furnace), there are two main systems in use to-day, and a third which is a combination of some of the features of each.

In the first system the stock is drawn from the bins into large round buckets, whose bottoms consist of a cone, or "bell," attached to a rod running up through the center to a hook at the top. This bucket is then transported to the bottom of the hoist and sent up, hanging by the hook at its top, to the top of the furnace, on which it is seated and then dumped by lowering the hook on the central rod carrying the bell, which is merely a large conical valve. In this system the material does not break bulk from the bin to the furnace top.

This skip is usually filled from a motor-driven dumping car, with its body or dumping hopper mounted on a scale carried by the truck, called the scale car or larry. This car is traversed along in front of the bins and filled from them. It is then returned to a hopper or chute, which delivers into the skip when the latter is in its bottom position, and there dumped, returning for another load while the skip is hoisted to the furnace top.

In this system it will be seen the stock breaks bulk between the bins and the top of the furnace.

At some plants a combination of these systems is in use, in which the bucket with the bell bottom is never removed from the suspension truck on which it is carried, or only to a turntable serving it, and plies therefore only on the incline, being filled by a scale car exactly the same as a skip.

The bucket in this case virtually becomes a skip which dumps through the bottom while retaining its upright position, instead of being turned upside down, as is done with the regular skip.

The first type of distribution is shown in Fig. 23, which shows the Ford-Parks modification of the original Nieland top.

The second of these styles of hoisting is well shown by Fig. 16, which is the design of Alexander E. Brown, and with which in connection with the distribution at the top of the furnace we shall deal more at length later.

Many variations of each of these systems are in use. Very frequently in the case of the skip hoist the coke bins are arranged on each side of the skipway, and coke is spouted directly into skips without the intervention of the scale car, the bulk of the coke being taken by skipfuls instead of its weight. This is a very satisfactory system if the same coke is always used, but one liable to produce great derangement of the furnace if sudden changes are made from one coke to another of very different density.

The skip hoist is built with both single and double skips.

The advantage of the double skip is that it is perfectly counterweighted, without extra mechanism for that purpose, and that it has a very great capacity. It, however, labors under the disadvantage that it discharges the stock at two points, one each side of the central plane, rather than at one point exactly in the central plane, as is done with the single skip.

Where the irregularities of the distribution are not compensated or eliminated by suitable means, the lack of symmetry, due to the fact that the skips dump on opposite sides of the main central plane and on the same side of the central plane at right angles to it, is likely to cause very serious derangement of the working of the furnace. The elimination of these irregularities is made much easier if the skip dumps exactly in the central plane.

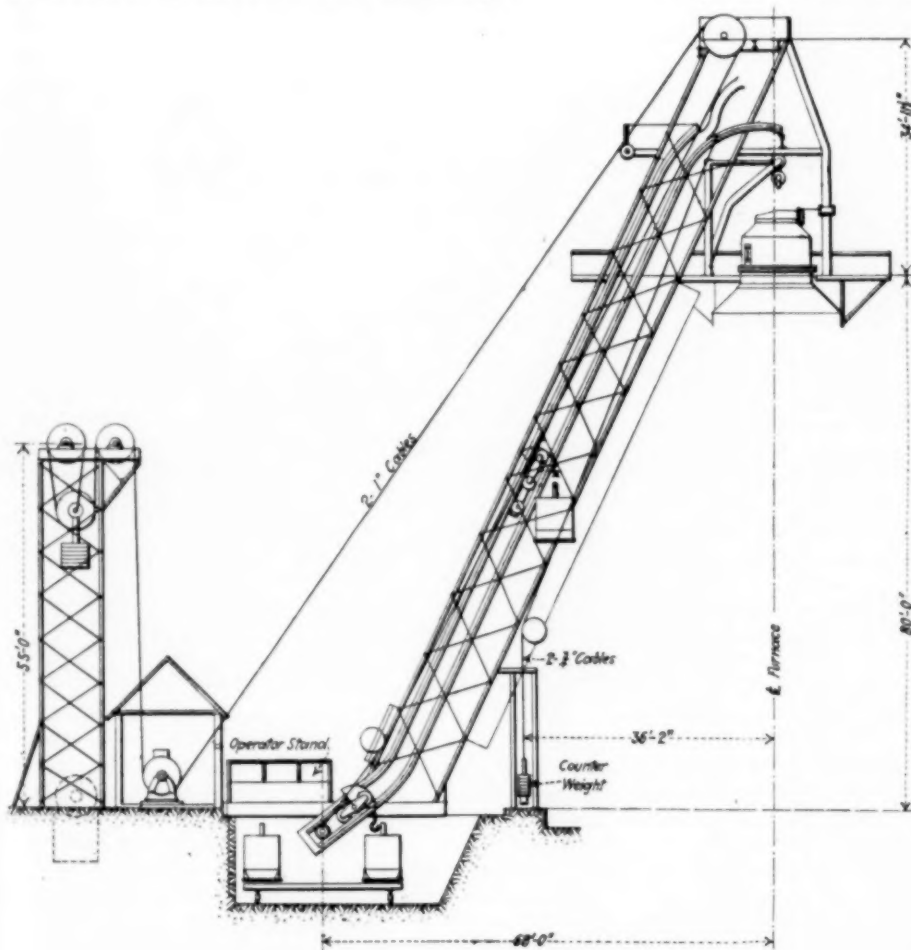


FIG. 23—FORD-PARKS SYSTEM OF BUCKET FILLING

Different systems of rotating the buckets are in use, but this subject can more appropriately be discussed under the head of stock distribution. Various methods have also been used for lowering the bucket onto the furnace top after it reached the proper position. But while these differ from the one illustrated, they do not differ sufficiently in principle to make detailed description necessary.

In the other system a sort of tank, either rectangular, round or elliptical, with wheels on one side, runs from a pit beneath the filling level to a hopper above the furnace top, where it turns upside down and dumps, then returns to the bottom, its travel being thus confined entirely to the inclined track running to the furnace top, known as the skipway, the tank itself being known as the skip.

A double skip was put in use at the Pueblo plant of the Colorado Fuel and Iron Company a number of years ago, designed by Mr. E. G. Rust, in which the advantages of both the single and double skips were obtained by a most ingenious design. Both skips run in the central plane and occupy the same positions at top and bottom. Of course when one is at the top the other is at the bottom, and there is no fouling in those positions, but in order that they may pass each other the tracks diverge from one another in the vertical flumes starting from the top and bottom so that they are separated vertically at the middle of the skip bridge by a sufficient distance to allow the under skip to pass beneath the upper. The gauge of the track for the upper skip is wider than that for the lower, which runs between the rails of upper track. The deepening of the skip bridge at this point tends to give it additional strength at the place it is most needed.

This system has been in use at the Pueblo plant for a number of years, but for some unknown reason its use has never extended very widely.

#### Location of the Hoisting Sheaves

One of the difficulties met in skip hoist design is that commonly the hoisting rope must run over a sheave located at the upper end of the skipway and come back over the top of the skip in order to be out of the way of the stock when the skip dumps. This brings the rope above the skipway while the hoisting engine is generally most conveniently located underneath the skipway.

Various arrangements have been used to overcome this difficulty. In one design a truck is used which carries the skip at its upper end and practically pushes it up the incline, the skip being pivoted to the truck and having an auxiliary pair of wheels in the front. In this case the sheave is put below the skipway and is far enough below the skip when it dumps to be out of the way. This puts the rope under the skipway where it is most desirable to have it.

In a number of cases the ropes have been carried clear over the top of the furnace, and the hoisting engine placed on the opposite side in order to overcome this difficulty, while in one well known type of top two guide sheaves are used on each skip rope, in addition to the main hoisting sheave, in order to get the rope out of the way at the top and pass it back underneath the skipway.

In the Brown design of skip hoist the difficulty is solved by the use of the single skip, and by putting the hoisting sheave in a plane parallel with the skipway as shown in Fig. 16 so that the hoisting rope can be returned over one side of the skipway to the engine house beneath it.

Probably other solutions of this apparently trivial problem have been attempted or made, but these are the ones best known and most used.

#### Dumping the Skip

The method for turning the skip over to dump is universally the same. The main rails of the skipway bend down from the incline and run in level when they reach the top of the hopper, but there are two additional rails set to a somewhat wider gauge which continue on in the main line of the skipway. These are set far enough apart so that the front wheels can pass through them without touching the wheels, all being outside the skip. But the rear wheels have a supplementary tread outside the regular one, which comes onto these supplementary rails just where the main rails bend down from their straight line. This carries the rear wheels on up while the front ones go forward on a level line, and in something less than twice the length of the skip it

is turned up to an angle of forty-five degrees or more and so emptied completely.

#### Counterweighting

The bucket type of filling must use a counterweight in order to avoid excessive consumption of power, and somewhat more difficult control in handling its loads, because from the nature of the case the bucket type of filling must be of the single-hoist variety and therefore unbalanced.

Various methods of arranging the counter-weight are in use. Very generally a vertical tower is used of somewhat less height than the furnace, in which a weight is raised by the counter-weight rope, when the skip is going down. A system of sheaves is used like an ordinary block and tackle in order to get the required counterweighting effect with a short travel by using a proportionately heavier counterweight.

The Brown skip hoist when designed for a single skip eliminates the problems of reversing the engine and of counterweighting the skip by using a hoisting engine in which the drum is connected to the engine shaft through a friction clutch under the control of the operator instead of the ordinary hoisting engine in which the drum is keyed to its shaft and positively connected to the engine shaft through gears. The engine runs always in one direction and the skip is hoisted by throwing in the clutch. On the return trip the skip is allowed to run back by throwing out the clutch and controlling the drum with a brake.

The better type of engine which can be applied by eliminating the need for reversing makes this system more economical, in spite of its loss of power in hoisting the unbalanced skip, than the ordinary system is with the skips balanced, but using the very uneconomical type of reversing engine previously described. The Brown system, however, is open to the objection that it requires some skill on the part of the operator in throwing in and out the clutch and lowering the skip with the drum brake, whereas the counterweighted system can be made entirely automatic as to control, etc., by the use of the slow starting and slow stopping devices previously described.

#### Larry Cars

These are almost always used with skip filling and sometimes also with bucket filling. Their essentials are in general always the same, but the details of their arrangement varied greatly. These essentials are a truck, motive power for the truck; a buffer with quick and complete means for discharge and scales supporting the buffer on the truck.

Frequently also there are means for operating the gates. Several of the preceding illustrations of bins have shown scale cars also and from these a good idea of the standing types may be obtained. They may be either of the suspended type with their rails elevated close up under the bottom of the brim which has the advantage that nothing can fall from the chute or buffer onto the rails; or the rails may rest on ties on the ground as in standard railway track.

Many systems of discharge scales have been used and in general the details of the design of these cars is adapted to the conditions of the individual case and the judgment of its designer.

A modified type of larry is used with the original bucket type of filling in which the buckets are removed from the hook of the hoisting truck and taken directly to the bins to be filled, but in this case the more appropriate name of scale car is used.

These differ from the larry principally in having a platform in which the bucket rests instead of a buffer; while, like the larry, their detailed design is adapted to the condition of the given case.



### Scales

One of the most important details of the whole operation of charging a furnace, which as a whole is probably the most important single part of blast furnace operation, is the weighing of the materials. It is customary to look upon the blast furnace as a rough, not to say crude apparatus. This view is justified in part by the enormous forces which it must handle and keep under control. But as a matter of fact in spite of its size it is one of the most sensitive pieces of apparatus in industrial use and runs on smaller margin of safety in fuel than any other of our great industrial operations. Changes of the "burden" (a technical name for the weight of ore for a given fuel charge) as small as one per cent are not infrequently used in adjusting the operation of the furnace to make the kind of iron de-

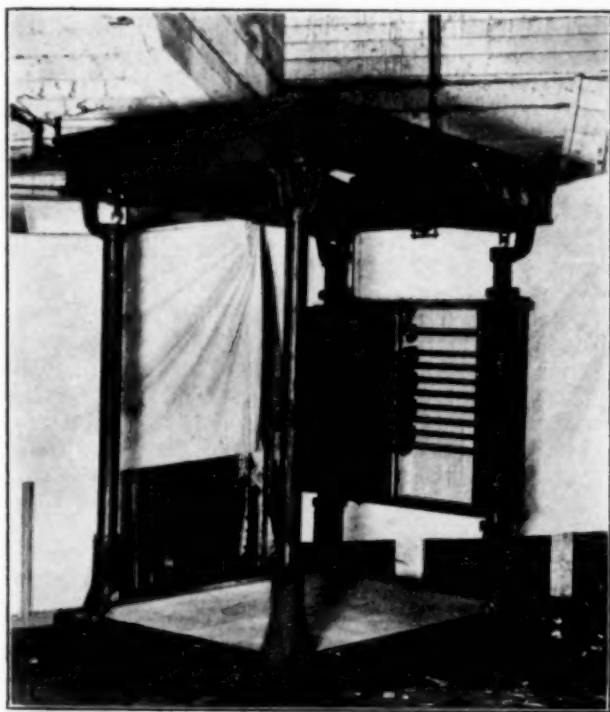


FIG. 24—FURNACE CHARGING SCALE

sired with a minimum consumption of fuel. Changes of two or three per cent are as large as are often made to adjust for the ordinary variations of operation. Such adjustments necessitate accurate weighing, and the lack of this has often been accountable for bad furnace operation, and even more numerous cases in which claims of remarkable furnace work were based upon inadequate or incorrect knowledge of the weights of the different materials actually used. Not infrequently the consequence has been a bitter disappointment when the book inventory of the material on hand was compared with the actual stock of such material.

Cases are on record too numerous to mention in which the books have shown the presence in the stock house of thousands of tons of material, and the financial returns have been estimated on this basis only to find on investigation that the material, so plainly shown by the books, had been put through the furnace and was conspicuous by its absence from the stock house. This has sometimes happened with the knowledge, or even through the deliberate action of a dishonest superintendent, but has also often happened to an honest one who had too great confidence in his scale weights. This condition is now so well understood that the financial management generally insists on a monthly or weekly

inventory of the actual material on hand, and its comparison and reconciliation with the figures taken from the furnace books.

The scales used for charging purposes have to meet certain special conditions, and therefore were early designed by the scale makers for this purpose, and given the name of "charging scales."

The type of these in common use with the barrow system of filling is shown in Fig. 24 (Fairbanks & Co.). These are platform scales with the base sunk in the floor of the stock house so as to bring the platform level with the floor. In recent years these have nearly always been of the suspended type, the platform being carried by four suspension rods from the scale-levers over head. This takes the latter up out of the way and out of the dirt in which they were necessarily more or less buried with the older type of scales, in which the levers were in a pit below the platform.

A special condition that these scales have to meet is that as a general thing at least three kinds of material have to be weighed—fuel, ore, and flux (limestone or dolomite), and a definite amount of each is required for each charge.

In order to meet these conditions the scales are built with from three to six separate beams, any one of which can be lifted up out of operation or lowered onto a frame depending from the main beam, so that the two operate as one. The main beam is usually used to balance the weight of the empty barrows, and one of the secondary beams is then thrown in for each material to be filled, its pea being locked fast for the charge weight wanted, this particular beam then rises and falls according to the weight of the given charge in the barrow. When this has been adjusted by adding or subtracting material this beam is thrown out and that for the next material thrown in.

The introduction of mechanical filling brought about the necessity for a different arrangement of the scales, and the trucks which carry the buckets to the bins in the bucket system of filling are provided with scales under the platform on which the bucket rests; or in the case of the larry car used with the skip, the hopper is carried directly by the scales which constitute a part of the truck. The same system of beams has in some cases been used as in the stationary charging scales, but in more recent years it has been found extremely desirable to use a recording type of scale.

The first of these ever installed, so far as known to me, was built by the Streeter-Amet Company of Chicago, for the order of Mr. W. L. Klutz, now vice-president and general manager of the Central Coal and Iron Company, then superintendent of the Thomas plant of the Republic Iron and Steel Company.

This scale carries a large round dial, around which a pointer travels as the weight on the scale increases. Certain fixed markers are attached to the face of the scale, in positions corresponding to the burden of the different materials wanted, and the scale car operator can then watch the gradual rising of this pointer toward the desired weight, so securing much more accurate weights than is possible when the only indication given by the scale occurs during the brief instant while it is in balance, since then it is generally overloaded before the supply of material running in can be cut off.

These scales are also provided with a paper tape, and by means of a lever, which is pulled when the correct point is reached for each portion of the charge, the actual weight on the scales is stamped on this tape, which is locked up in the scale box, entirely inaccessible to the operator. At any interval desired, generally once a day, this tape may be taken out and examined to see the accuracy of the weights actually obtained, as compared with those called for by the pointers.

The moral effect of this on the scale car operator is tremendous, and vastly better results can be secured by the use of such an apparatus.

The writer became general superintendent of the plant mentioned between the time that this experimental apparatus was ordered and the time it was put in operation. The change produced in the accuracy of the weights obtained was almost beyond belief and the work of the furnace on which the scale was used immediately improved very much.

Since that time the American Kron Scale Company has brought out a similar device by which the same results may be obtained. The practical importance of this matter is so great, and the moral effect upon the scale car operator caused by the knowledge that a continuous record is being made of the way in which he is doing his work, are so important that it is doubtful if any furnace is justified in doing without such equipment.

The scales on scale cars are subjected to a very serious service. They not only have to receive the impact and shock of the incoming material, but they have to stand the much more serious shocks arising from irregularities in the track on which the scale car runs. The great inertia of the charge on a loaded scale car causes enormous stresses on the knife edges even with apparently insignificant irregularities in the track. For this reason switches, cross-overs, and other breaks and irregularities in scale car tracks should be avoided to the greatest possible extent. Moreover, these cars should always be provided with springs over the axle boxes, or in other suitable location. These springs should be the softest, that is, have the maximum travel for a given change in stress, permitted by the conditions, as in this way the springs absorb the shocks arising from the irregularities of the track and keep them off the knife edges.

I have seen scale cars built entirely without springs, and at the same time heard the furnace managers complain bitterly that it was impossible to get his scales to stand up and give accurate service, without his realizing the reason.

Means have been provided whereby the weight of the charge hopper was lifted off the knife edges except during the time that it was actually being weighed. But it is ordinarily difficult to get scale car operators to use this device. There seems no reason why it should not be made to interlock with the traversing motor of the car, so that the latter could not be moved except after relieving the knife edges of the scales from weight.

This may seem a matter of too little moment to deserve such serious mention, but when the importance of accurate weighing previously mentioned is considered, and when it is realized how utterly unreliable the best scales become when their knife edges are even slightly worn, it is believed that the stress laid on this subject will be justified.

### Electrochemical Progress in Norway in 1913

Mr. I. J. Moltkehansen, Managing Director of the Fredrikstad Elektrokemiske Fabriker A. S., communicates to us the following notes which we will assume be interesting to our readers.

The Fredrikstad Elektrokemiske Fabriker A. S. expects to be operating by the middle of 1914 and will manufacture metallic sodium, sodium peroxide, and other sodium compounds such as sodium cyanide, also possibly potassium chlorate.

The sodium works at Vadheim in Sogne has largely increased its output during 1913, having now a producing capacity of possibly four hundred to five hundred tons of sodium per year.

The electric zinc furnaces at Sarpsborg (similar to

those at Trollhättan, Sweden) are said to be running profitably. Other proposed electric zinc smelting processes do not seem to have yet reached that stage. Mr. Tharaldsen of Trondhjem is reported to have developed a new electric zinc smelting process at the Ilen Smelteverk. Mr. Raeder of Kristiania is also developing an electric zinc furnace, being backed by a German firm in Nerpelt, Belgium.

The Skienfjord Kraft A. S. has rented 10 to 15,000 horse-power to a German firm, for the manufacturing of silicon and calcium carbide. Prime Minister Gunnar Knudsen is the president of this power company, which is developing several water falls near Skien. Every week there are reports of new companies utilizing large and small water falls in all parts of the country for the purposes of light and power.

In this connection it is interesting to note that, at the same time, modern gas works are being erected in the smaller towns of Norway, mostly for heating and industrial purposes with utilization of the by-products.

The great water-falls of Bjlvfos in Hardanger, and Matre and Tyin in the Sogn district are now being developed. The Government is taking up the regulation of the river Nummedalslaagen by constructing dams and forming lakes in the highlands.

The "Societe Norwegienne de Nitrure" has acquired the Serpek patents for producing aluminium nitride in Norway, with a capital of ten million francs. A plant is being erected at Arendal.

The "Norsk A. S. for Elektrokemisk Industri" has increased its capital from 4 to 6 million kroner. It is not known exactly to what purpose this new capital will be put. This company has started many important electrochemical enterprises in Norway.

The Hardanger Electric Iron and Steel works, at Tyssaa near Odda stopped operations last year. This was one of the enterprises of the Norsk A. S. for Elektrokemisk Industri. This company has formed a mining company "Grong gruber" to work the large pyrites deposits north of Trondhjem. The Dunderland Iron Mining Company is reported as rehabilitated with English capital, to work the low-grade pure magnetite deposits, formerly worked by the Edison methods. They will be worked by a new electromagnetic concentrating and briquetting method, which is expected to give much more valuable and better results.

The old state silver mines at Kongsburg, which have been worked for nearly three hundred years, have in recent years increased their production, until it is now over twenty-two thousand pounds of silver per year. Other rich silver mines have been recently found in the same neighborhood and may soon be operated.

Plans are on foot to start large cement works near Drammen, using the rich limestone from the marble quarries at Lier; the capital is stated as two million kroner.

The "Alby United Carbide Factories" has obtained important concessions from the Government for the development of the Aura Falls near Molde. Mr. Blackstad is directing the company's activities in Norway.

Altogether, 1913 has been a very prosperous year for Norway, especially for the important steamer and sailing ships of the mercantile marine; crops have also been abundant, and there is plenty of money among the people. The importance of new railway connections to open up the country in all directions is being more and more realized. A new railway is projected to connect Kristiania and Trondhjem, having a branch to Molde and Aalesund. Another railway is projected north of Trondhjem to run to Narvik, with a possibility of running farther north. West of Kristiania a railway is being constructed from Kongsberg to Notodden and Telemarken, which will ultimately continue to Chris-



tianssand and Stavanger. A railway is also planned between Odda and Haugesund, near Stavanger. The railway between Kristiania and Drammen will probably be electrified in the near future; the railway being built between Myrdal and Fretheim in the Sogn will also be electric.

The Marconi wireless telegraph stations erected at several places on the coast have been of important aid to shipping during the year. In December, two 7000-ton Swedish steamers, the "Norrbotten" and "Italia," were saved by the Marconi station on the Lofoten Islands giving them instructions by wireless and telegraphing for pilots to conduct them to safety. A new station will be opened next summer near Stavanger, at the cost of 2 million kroner, which is expected to communicate directly with Newfoundland and New York.

Another great national enterprise, a connecting link between the Norwegians in America and the remaining half in Norway, is the "Norske Amerika Linje" which commenced in 1913 with two modern twin-screw steamers, the "Kristianiafjord" and the "Bergensfjord," running directly between Kristiania-Bergen and New York. The greater part of the capital of this company is held by Norwegian citizens in the U. S. A. As Norway will celebrate in 1914 the centennial of its present constitution, a great influx of visitors is expected from the United States, and the National exhibition at Kristiania will be opened May 17th of this year. It is expected that all the visitors from America will come by the new Norwegian steamships.

We have spoken at some length of the ocean steamship lines, since they play an important part in the industrial development of Norway, by opening new foreign markets for its products, and supplying new sources of raw materials. Other direct steamship lines from Kristiania to the Gulf of Mexico, Fredriksstad to South Africa, Australia and India have also had a prosperous year, and provide very cheap rates for Norwegian exports.

One Norwegian industry has not participated in the general prosperity, viz., the wood-pulp and paper industry. This industry is suffering from too great capacity of production, and raw material has advanced greatly in price. Large steamers arrive at Fredriksstad and Sarpsborg from Finland and Russia loaded with wood for the wood-pulp factories on the River Glommen. An English-Norwegian enterprise was the sending of a steamer of 1600 tons around the north of Norway and of Russia far into the River Jenissej in Siberia, under the guidance of Prof. F. Nansen, returning with a cargo of the much-needed wood. This water way promises much for the Siberian lumber trade and exports, as well as for Siberian importations from Europe because of cheap freights. Prof. Nansen was very cordially received by the Russian and Siberian authorities and a company has been formed to exploit this new trading route.

The Tekniske Hiskole of Trondhjem will turn out its first class of graduates in the summer of 1914. This Institute can at present accommodate 100 students in each year of a 4 years' course. It is projected to double the capacity, so that Norwegian engineers can get their higher technical education at home, instead of going abroad, as they do, mostly to Germany.

The idea of holding in 1916 a joint meeting in Norway, of the Bunsen Gesellschaft of Germany, the Faraday Society of England, the Société de Chimie Physique of France, and the American Electrochemical Society will meet with great enthusiasm in Norway, where the electrochemical industries have recently combined in a union for the protection of their common interests. The Editor of "Teknisk ukeblad," the foremost Norwegian technical paper in Norway, is forwarding the project enthusiastically.

## High-Temperature Resistivity of Refractories; a New Method of Measuring, with Results for Alundum

BY EDWIN F. NORTHRUP

In connection with the commercial application of electrothermics, even more than for its scientific interest, it is important to have a method for rapidly and precisely measuring the electrical resistivity of refractory materials at the high temperatures at which they are used. With such a method available not only trained investigators but students seeking subjects for these might employ their time to good advantage in obtaining a series of values for all the common refractories which are in use in electric-furnace practice.

While the writer has other problems which are absorbing his attention and is unable to find time to make a series of determinations of the resistivity of refractories, he was compelled to devise and test out a method, as supplementary to his other work, for measuring to a temperature of at least 1600 deg. C. the electrical resistivity of alundum cement. The test of the method proved that it is so easily applied and gives such concordant results that it seems wise to describe it here in the expectation that it will meet with favor and be put into practice by others and that we shall not have to wait long to have tables of constants and sets of curves of the electrical resistivities of the commercially useful materials which stand high temperatures.

That these measurements have not been made before is probably due to the fact that without special devices the difficulties in the way of making the measurements are insuperable. As the value of the data rapidly increases with attainment of higher temperatures it is necessary to be provided with a furnace which will meet the following conditions:

A temperature of over 1600 deg. C. must be obtainable.

The temperature must be uniform over a considerable length of the furnace chamber in order that all parts of the refractory being measured will be submitted to the same temperature at the same time, and this temperature must be under perfect control. The furnace chamber must be filled with an atmosphere of carbon monoxide, because, as will be subsequently shown, graphite makes the most suitable electrodes between which to clamp the refractory material being measured and graphite will burn up in an oxidizing atmosphere.

Alternating current must be used for the measurement. If a refractory material be clamped between two electrodes and then be submitted to a high temperature it will be found that when a feeble direct current is passed through it, it develops back electromotive forces as if it were a kind of storage battery. Electric conduction at high temperatures, in these cases, is probably a mixture of electronic and electrolytic conduction. The problem in making the measurement is, therefore, not different than the problem of measuring the internal resistance of a battery.

If the material being measured is clamped between two flat surfaces of conducting material, as graphite, a little consideration will show that there is no material available which can be used to press the two surfaces upon the refractory so as to give good contact without forming a shunt upon the resistance being measured. This difficulty, which for a time appeared to the writer unsurmountable, has been absolutely overcome as will later appear.

The measuring current must be conveyed to and from the material under measurement with something which conducts well when the temperature is over 1600 deg. C.

Up to 1600 deg. C. the temperature may be measured

with a platinum vs. platinum + 10 per cent rhodium thermocouple. A casing for the couple of Royal Berlin porcelain will stand this temperature provided the porcelain tube is not in contact with anything. As it is quite viscous at 1600 deg. C., it will be deformed by anything it touches and the glaze will cause it to adhere tenaciously.

In the measurement described this means was adopted for measuring the temperature and the temperature was not carried higher because of the limitation of the couple. The writer has under development a far superior method for measuring a temperature with very great precision which will be described in a later report. It is not an optical or radiation method.

All the requirements for accurately measuring the resistivity of refractories are met by the method which is now to be described.

The refractory material to be measured is first molded in three thin rectangular slabs. The size of these slabs, which was adopted in the measurement here de-

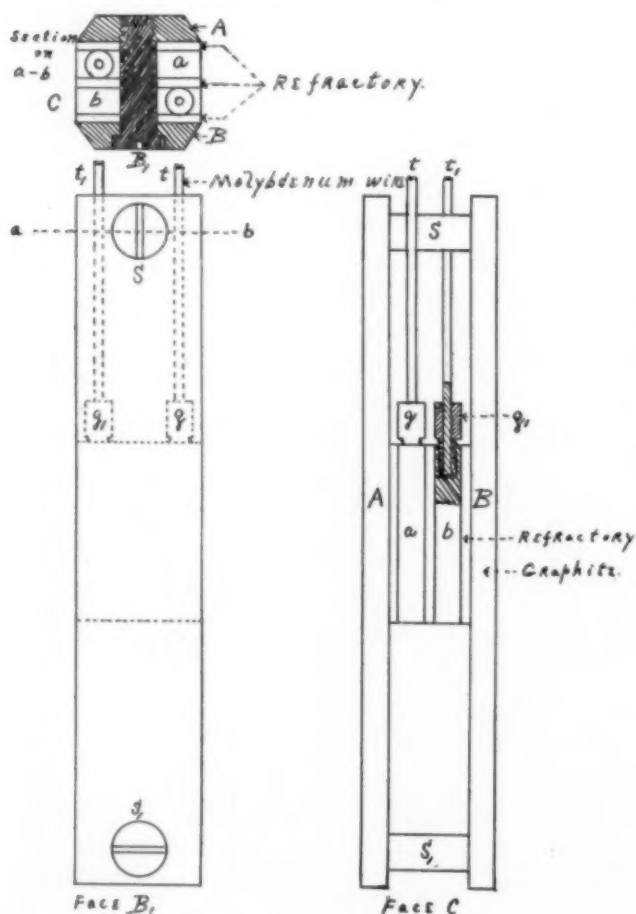


FIG. 1—ARRANGEMENT OF TEST

scribed, was width 3.4 cm, length 4.8 cm and thickness 0.25 cm. As the details for treating the refractory material to be measured would differ somewhat according to the nature of the material being measured, the description here given will apply specifically to the material which was measured in testing out the method. This material was a very finely ground alundum cement made by the Norton Company, Worcester, Mass., and designated by them as grade RA 355. To mold these slabs it is necessary to add to the cement a very small quantity of water and then press the material into a metal mold under considerable pressure. When dried out in a gas oven the slabs are sufficiently coherent to handle without breaking.

These three slabs are now clamped between graphite plates in the exact manner shown in the drawing, Fig. 1. In the drawing, *a* and *b* are two graphite plates of the same width and length as the slabs of refractory but about 0.8 cm thick. *A* and *B* are two other slabs of graphite of the same width as *a* and *b* but considerably longer. As actually used in the experiment the *A* and *B* slabs were made 9 cm long, but the writer's experience

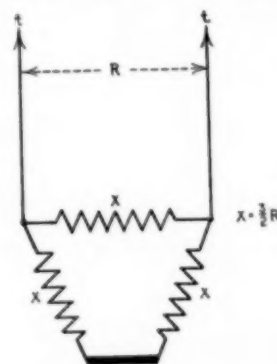


FIG. 2—ELECTRICAL CONNECTIONS

shows that they should have been made at least 25 cm long for a very important reason; the graphite screws *S* and *S*<sub>1</sub> serve to clamp tightly together the three refractory and the four graphite slabs, as Fig. 1 plainly shows. As there is more or less expansion or contraction of the refractory material when submitted to great temperature changes, it is necessary in order that uniform pressure be at all times maintained on the refractory pieces, that the slabs *A* and *B* be long enough so that the natural spring of the graphite may act to maintain the pressure on the refractory pieces.

Electrical connection is made in the manner indicated in Fig. 1 to the graphite slabs, *a* and *b*. The two wires which serve as terminals are made of molybdenum approximately 2 mm in diameter. This wire melts above any temperature obtainable in the furnace and as there is a CO atmosphere in the chamber the wire does not oxidize. The wires are fastened to the slabs *a* and *b* with graphite screws *g*, in the manner shown in Fig. 1. It will be noted that we now have an electrical circuit between terminals *t* and *t*<sub>1</sub>, which is like that diagrammatically shown in Fig. 2.

If we call *R* the measured resistance between terminals *t* and *t*<sub>1</sub> and *x* the unknown resistance of each one of the similar slabs of refractory, we have

$$R = \frac{x \cdot 2x}{3x} \quad \text{or} \quad x = \frac{2}{3} R \quad (1)$$

If *l* is the thickness of one slab and *S* is its cross-section, namely its width by its length, and  $\rho$  its specific resistance in ohms per cm<sup>3</sup>, we have

$$x = \frac{l}{s} \rho \quad (2)$$

From Eqs. (1) and (2)

$$\rho = \frac{3s}{2l} R \quad (3)$$

With the dimensions chosen for each of the slabs of refractory  $3s/2l$  equaled, within the limits of accuracy of the measurement, just 100. Hence

$$\rho_t = 100 R_t \quad (4)$$

The subscript *t* means that  $\rho$  and *R* are determined at the measured temperature *t*° C.

The arrangement shown in Fig. 1 was placed in the bottom of the tubular chamber of the furnace. (This furnace was described by the writer in METALLURGICAL AND CHEMICAL ENGINEERING, January, 1914.) The two molybdenum terminal wires passed up through a cylindrical cover piece of baked lavite which tightly closed the top of the furnace. The thermocouple tube passed through this cover piece and the end of the



thermocouple was brought close to the refractory pieces being measured. The two projecting molybdenum terminals were joined to the X posts of the bridge arrangement to be described, and the thermocouple e. m. f.'s were read with a potentiometer. The cold junction of the thermocouple was maintained at 0° C. by being located in ice water in a Dewar flask.

Experiences with this and previous measurements

had taught the writer that the chemical composition of all refractory materials is not in an equilibrium position when raised to a high temperature which is higher than that at which it has previously been raised. It therefore, becomes necessary before starting to make measurements to pre-heat the material to a temperature as high or higher than that which one intends to reach in the measurement. Before beginning the measurement, for obtaining final values, the material was heated twice to over 1500° C.

As was expected, it was found impossible to make measurements having any accuracy using direct current. As soon as attachments were made to the X post of a bridge a galvanometer of 1 megohm sensibility would fly off the scale. The writer does not like to make measurements with alternating current using a

telephone as a detector, because a telephone does not tell whether the balancing resistance is too high or too low. He prefers an electro-dynamometer method. This method has been described by the writer in his book on "Methods of Measuring Electrical Resistance," paragraphs 1113 and 1120. The method enables one to measure the internal resistance of a battery or any device which includes an electromotive force in its circuit

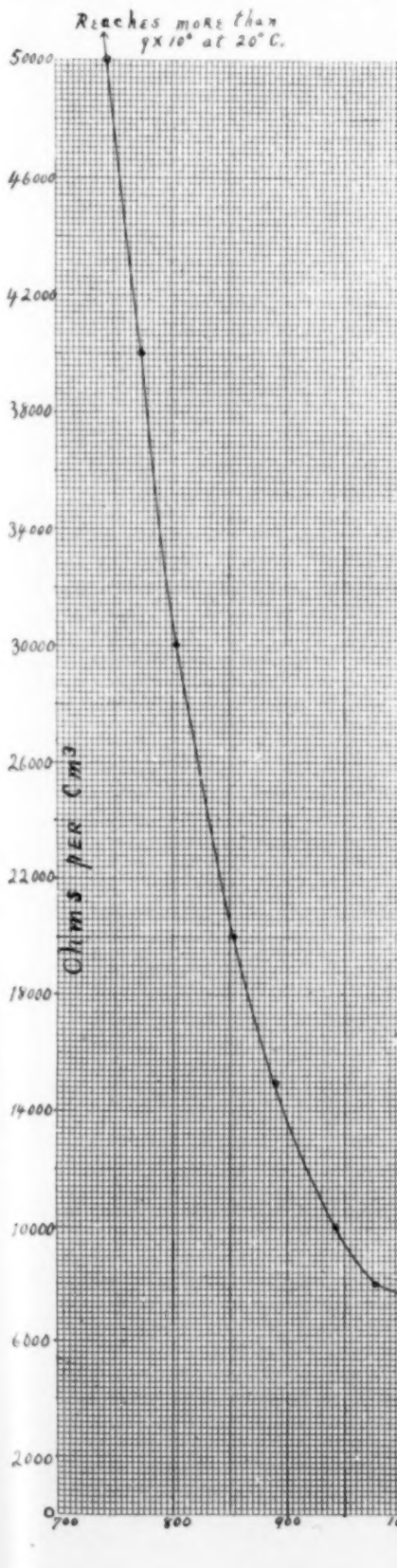


FIG. 4—RESISTIVITY OF ALUNDUM AS FUNCTION OF TEMPERATURE

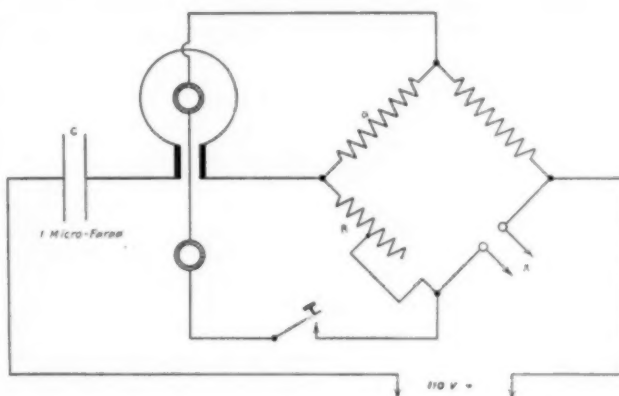


FIG. 3—METHOD OF MEASURING ELECTRICAL RESISTANCE

with quite as much ease and certainty as one would measure a metallic resistance. The electro-dynamometer suitable for the purpose is the one described by the writer in paragraph 1001 in the above-mentioned book. This was the instrument used in obtaining the resistivity of alundum cement and the method as applied will be readily understood from the diagram, Fig. 3. 110-volt alternating current was used. The condenser C in the diagram was 1 micro-farad and the current which passed through this condenser was quite sufficient for adequate sensibility.

The measurements of temperature and resistance were taken with rising temperature in the furnace. This is preferable to taking measurements with falling temperature because with rising temperature everything is expanding and the refractory pieces are maintained more tightly clamped between the graphite slabs.

The curve, Fig. 4, shows the results obtained.

—It was suspected that the inflection in the curve which occurs at a temperature of 1100° C. was an error. Therefore, the clamping pieces were removed, refractories examined and everything re-assembled and the measurement was repeated. The inflection occurred the second time at almost precisely the same point and it is concluded that it is a real phenomenon connected with the material. Whether it exists or not, however, has small bearing upon the engineering aspects of the properties of alundum.

The greatest chance for error in these measurements arises from the difference in the resistance which may arise from varying pressure of the graphite slabs upon





first combined with sulphur, the latter acting as a carrier to deliver the chlorine to the metals of the sulphides and then make its exit with the gangue. This proposition leads to the theory that there are zones of chloridization in the tube, the positions of which are subject to shifting brought about by the adjustment of supplies of ore and chlorine.

By a proper regulation of the ore and gas supplies, and the addition of air, the temperature due to chemical reaction can be controlled. After this partial chloridization in the tube mill, the ore is conveyed to a roasting furnace, preferably of the multiple-hearth type. Here the partially chloridized ore is subjected to the action of heat, furnished by the burning sulphur or supplied from an external source. The heat decomposes the iron and similar chlorides and liberates chlorine, either free or as hydrochloric acid, leaving the metals of the decomposed salts in an inert oxide condition. The chlorine or hydrochloric acid liberated unites with the sulphides or oxides of silver, copper, lead and zinc, forming chlorides of these metals.

In order to produce the desired action, the chloridizing agents should be in excess, and means are provided, therefore, for the collection of chlorine gas escaping from the main chloridizing hearths of the furnace. One way of effectively conserving the excess chlorine is to pass the furnace gases containing this element through a bed of sulphide ore. In the use of a six-hearth furnace as shown in the diagram, the ore from the tube mill is fed into hearth No. 3 and progresses downward. Hearths Nos. 1 and 2 are supplied with raw sulphide ore which circulates through these hearths. The gases enter these two upper hearths from the lower or main chloridizing hearths, and filtering through the sulphide ore pass to the stack. A portion of the ore from the two upper hearths is by-passed to hearth No. 3, the quantity depending on the rate of absorption of chlorine by the raw sulphide ore.

#### Solution of the Chloridized Metals

The ore thus treated in the furnace is passed to an agitator to which water or mill solution is added. The heated ore and the heat evolved by the process of solution is sufficient to make possible the solution of such chlorides as lead and silver. Chlorine may be added at this point if found necessary to bring the gold into solution. From the agitator, in which all the metals go into solution as chlorides, the pulp is treated in properly designed filters where the gangue, ordinarily consisting of silica, sulphur and the oxides of iron and manganese, is retained.

The combination of a mechanical agitator and blow-case has proved most effective in accomplishing solution of the chlorides. This apparatus is constructed of impregnated wood like a large barrel. When solution is complete, steam is admitted which forces the pulp through the filter; and by forcing steam through the residue after the solution had been removed, a highly efficient wash is obtained with a minimum of water. The filtering medium is asbestos cloth. The filter residue may be sluiced over amalgamated plates to recover any gold or silver not dissolved.

#### Concentration of Solution and Precipitation of Metals

The further treatment of the solution depends on its metallic content, particularly zinc, and on the burden of the sparingly soluble salts, *e.g.*,  $\text{PbCl}_2$  and  $\text{AgCl}$ . The solution is circulated between the weak-solution storage tank and the agitator until its metal contents justify refining, after which it is treated according to the following general scheme. It is first agitated in the presence of metallic copper which precipitates gold and silver. The solution is decanted and agitated with metallic iron to precipitate copper. Lead is then re-

moved by precipitation with metallic zinc; and, if necessary, the solution is treated with zinc oxide, carbonate or silicate, chlorine and sulphur dioxide, to remove iron, manganese or lime. These latter impurities may have existed in the solution on account of insufficient decomposition in the roasting furnace, or may have been introduced in the substitution process described above for the removal of metals. The zinc precipitant for this latter purpose may be either the natural minerals or zinc oxide obtained by the roasting of zinc ores.

#### Electrolysis of Fused Zinc Chloride

After the above treatment the solution contains only zinc chloride. It is passed to the vacuum evaporators where the moisture is removed, and then fed to electrolytic cells in a fused condition. Metallic zinc is deposited and chlorine liberated for reuse. The cells are operated at a temperature of about 450 deg. C., and the gas escapes at approximately the same temperature. It may be passed under the vacuum pans to aid in evaporation and at the same time be cooled to a temperature suitable for use in the tube mill.

The various precipitates of gold, silver, copper and lead are collected separately in filter presses, dried, melted and cast into bars.

#### Chemical Data

Practically all the work done on this process hitherto has been directed to obtaining results, and not particularly to chemical interpretation of all the reactions involved. Although conditions apparently are favorable to the formation of sulphates, particularly that of lead in the roaster and agitator, the fact remains that their occurrence has not been observed in any tests. For example, a recent test on an ore containing 6 per cent lead and 3 per cent sulphur yielded an extraction of over 99 per cent lead. This test was run under conditions apparently favorable to the formation of lead sulphate, and yet this did not appear.

The following statements are based upon actual experience with the process. While the metal precipitants in contact with solution are always in excess, the substitution reactions are practically quantitative, as the solution during the refining stage is neutral. Any acidity caused or acquired is utilized in the agitator treatment of the ore from the roaster. The necessary hydrochloric acid is obtained from the decomposition of  $\text{S}_2\text{Cl}_2$  in the dust chamber.

The successive precipitations occur rapidly, and all the precipitants are granular and easily filtered. Owing to the high solubility of most of the chlorides formed, the solutions can be maintained in concentrated condition.

The degree to which ferric chloride is permitted to form and enter solution is determined by the quantity of ore containing oxides, carbonates and silicates which are available for treatment.

The metallic precipitates are freed from any associated metal used as precipitant by washing the precipitate with a solution of its chloride.

The larger the scale on which this process has been applied, the easier has it been to maintain control of the operations; and its application to commercial practice has been anticipated only in the light of "continuous and concurrent operations, where ordinary human beings are a function."

The electrolysis of fused zinc chloride has proved a much more simple operation than the electrolysis of sodium chloride solution. The chlorine loss has been found so low as to be almost negligible as a cost factor. The high efficiency of the zinc chloride cells has established commercial zinc chloride as the source of chlorine for starting operations and for replacing such less as may occur. The ore itself has proved the most satisfactory storage for chlorine.

## Notes on Chemistry and Metallurgy in Great Britain

(From our Special Correspondent)

### Cement Testing

Mr. W. L. Gadd recently read a paper before the Concrete Institute which deserves the attention of all who are interested in the testing of cement. His main object was to call attention to the fallacies existing in certain recognized processes of testing, not excepting some of those found in the British Engineering Standards Specification.

First, with regard to time of setting, the author said that the object of exposing the sample spread out to a depth of 3 in. for 24 hours seemed to be partly to cool the cement to a normal temperature, and partly to get it under the conditions similar to those resulting from keeping the cement in sacks or casks for a few weeks. The cooling manifestly could be effected without exposing the cement to the air; and the results of storage were very various.

He made experiments with two large samples of cement, one recently ground and the other ground a month previously, which were put into sacks and taken to warehouses at six different works. Six samples were the produce of rotary kilns and six of chamber kilns. After fourteen days the sacks of cement composing each sample were well mixed, sampled and put aside for a further fourteen days, when another mixture and taking of sample was carried out.

The tests showed that in most cases the time of initial setting was quicker after both fourteen and twenty-eight days; but there were two exceptions, one of which first showed and afterward quickened, and the other quickened and afterward became slow. This went to show that cement kept in sacks in a dry condition might become either slow or quick in time of setting.

He found that the results obtained from samples aerated for twenty-four hours, as laid down by the Engineering Standards Specification, did not agree with those of the bulk sample from which they were taken, and it was demonstrated that the time of setting was affected by the conditions of storage, and although the samples tested varied considerably in composition, they all exhibited erratic behavior in this respect.

Direct experiments with pure dry air showed that this did not affect the setting time; but moist air free from carbon dioxide had a marked effect, while absorption of carbon dioxide was proved to considerably accelerate the setting time.

With regard to sieves for determining the degree of fineness, he had examined many rolls of wire cloth strictly agreeing with standard specification, but yet totally inaccurate for their intended purpose. The real standard should be the size or area of the holes in the sieve; and the diameter of the wire threads and their number per inch were of secondary importance.

The size of the sieve itself also affected the result. A very fine sample he found to leave 3.5 per cent on a large sieve, and 5.6 per cent on a smaller one—a difference of 37 per cent.

The determination of the specific gravity was still laid down in the Standards Specification, but it was not really any indication of a proper degree of calcination, and it depended to a great extent upon the age of the cement, and whether it had absorbed carbon dioxide and water. These were Butler's conclusions, and he entirely agreed with them.

Then, again, certain specifications directed that the specific gravity should be taken after drying the cement at 100 deg. C.; but this was quite useless, because carbon dioxide would not be expelled below 300 deg. C.;

and he was of opinion that the only reliable guide in the case of doubtful cements was chemical analysis.

Standard sand was generally supposed to give the best results obtainable with any given sample of cement in respect to tensile and crushing tests; but this view was not correct although the standard sand ensured comparable results. Then, again, different countries used different standard sands, and it had been proved that the crushing resistance of concrete made with the same cement varied with the size as well as with the nature of the aggregate.

The autoclave test was only a revival of Dr. Erdmeyer's high-pressure steam test, which German cement experts had rejected as unreliable and misleading; and the results of American and Canadian research showed no ground for its adoption.

On the question of free lime the author remarked that the view that unsoundness of cement was due to free lime had been strongly held for a long time and was now widely accepted; but the theory that the expansion of cement was due to the presence of free lime was not supported by any authenticated facts. His opinion was that unsoundness was most probably caused by an abnormal silicate, very possibly dicalcium silicate, an unstable compound which disintegrated slowly with resulting increase in volume.

### The Institution of Petroleum Technologists

Last month the guarantors of a fund for the foundation of an Institution of Petroleum Technologists held a meeting for the purpose of establishing this new institution. The desirability of forming such a society has been very apparent during recent years not only for the technologists but for the benefit of all who are engaged in the petroleum industry. The main objects of the institution are the collection and dissemination of reliable information in all branches of petroleum technology; to afford facilities for interchange of ideas on methods of production, refining, transport, storage and uses of petroleum and shale oil and their products; and to insure the attainment of a high standard of efficiency by technologists.

On the proposition of Professor Vivian B. Lewes, seconded by Mr. A. C. Adams, Sir Boverton Redwood was unanimously requested to accept the office of president. After accepting office, Sir Boverton announced that more than seventy applications for membership of the institution had been received.

### Market Prices, December, 1913

Higher			Lower		
	£	s. d.		£	s. d.
Zinc, ton	2.	6	Copper sulphate	1.10.	0
Iron, Cleveland	5		Shellac, cwt.	4.	0
Scotch pig	7		Tin ore	12.	0
			Tin standard	8.	0
				£	s. d.
Aluminum				85.	0
Alum, lump loose, per ton				5.10.	0
Antimony, Star Refulus, ton				28.10.	0
Borax, British refined crystal, cwt.				18.	6
Copper sulphate, ton				22.10.	0
Caustic soda, 70%, ton				10.	8
Copper ore, 10 to 25%, unit				11/3 to 11.	3
Ebonite rod, lb.				4.	6
Hydrochloric acid, cwt.				5.	0
India rubber, Para, fine, lb.				3.	1 1/4
Mica, in original cases, medium				3/6 to 6.	0
Petroleum, Russian spot, gal.				9 1/2	
Quicksilver (Spanish) per bottle				7.10.	0
Sal ammoniac, cwt.				2.	2
Sulphate of ammonia, ton				13.	0
Sulphur, recovered, ton				5.10.	0
Shellac, cwt.				4.	8
Platinum, oz., nominal				9.	5
Tin, ore, 70% per ton				£100-	2
Zinc, Vienne, Montagne, ton				25.12.	6

Colorado plants of the A. S. & R. Co. smelted 683,082 tons of ore in 1913, producing 293,836 oz. gold, 13,194,944 oz. silver, 136,247,052 pounds of lead, and 7,119,089 pounds copper. The gross value of the production was \$20,996,305.



## Presentation of the Perkin Medal to John W. Hyatt

### Interesting Notes on the Early History of Celluloid, Continuous Water Filtration and Other Inventions of Mr. Hyatt

The eighth impression of the Perkin gold medal for important work in industrial chemistry was presented on January 23 to Mr. John Wesley Hyatt, the inventor of celluloid, continuous water filtration, his roller bearing system, etc., at a joint meeting of the New York Sections of the Society of Chemical Industry, the American Chemical Society, and the American Electrochemical Society.

Mr. Gustave W. Thompson, chairman of the New York section of the Society of Chemical Industry, presided. The meeting was well attended and the occasion most enjoyable.

The chairman, Mr. Thompson, discussed in his introductory speech scientific imagination as the chief faculty required in men up to the mark to become Perkin medalists. The beloved dean of American chemistry, Professor Charles F. Chandler, followed with a record of Mr. Hyatt's life work and formally presented to him the Perkin medal. Mr. Hyatt, sprightly in spite of his seventy-six years, expressed his sincere thanks and gave a most interesting account of the invention of celluloid and a description of his sugar-cane mill. The proceedings were concluded by Dr. Frank Vanderpoel, who gave some delightful personal reminiscences from his association of many years with Mr. Hyatt.

#### Chairman's Address

The opening address was made by the chairman, **Gustave W. Thompson**. After some brief remarks on the origin of the Perkin medal, he continued:

"The medal is awarded for valuable work in applied chemistry. Whatever the future may have as interpreting the grounds for merit, in the past it has generally been considered that this work should be in the nature of original or inventive work which has proved of great public value. The question I would propound to you to-night is: What is the mental faculty which has made the recipients of the Perkin medal what they are? In what respect do these men differ from their fellow chemists, which has enabled them to be so successful in the application of chemistry to the arts? \* \* \*

"In 1870, Tyndall delivered his famous discourse on the 'Scientific Use of the Imagination.' In this discourse he showed the value of the imagination properly made use of in solving some of the most difficult problems of physics. Tyndall has shown us how the imaginative mind, seeing resemblances in things, can supply the missing parts in such resemblances, those missing parts being hidden from the senses.

"It was this power of the imagination which enabled Kekule to lay the basis for the working out of the structure of many complex organic compounds, which work has been of incalculable benefit to chemical science and industry, and thousands of instances could

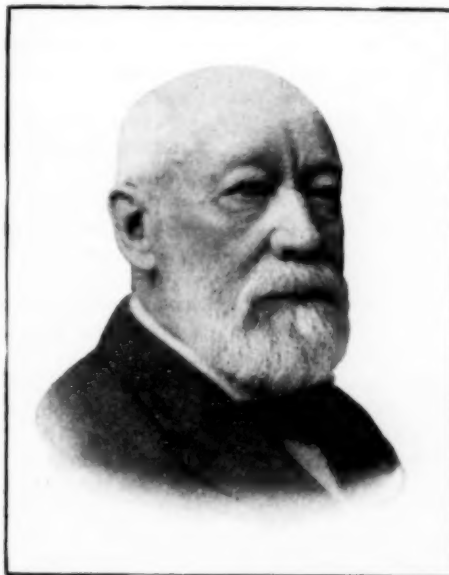
be given showing that practically all of the progress made in the science of chemistry has been due to this proper use of the imagination; but considering the work done in applied chemistry, we see clearly that it was the imagination of Herreshoff that enabled him to develop the metallurgy of copper, and of Behr in his work on the separation of the oil contained in the germs of corn, and of Acheson, who saw in his imagination that, if flocculating agents existed, there were probably also *de-flocculating* agents, and of Hall, who believed that somewhere there was a solvent for alumina, from which aluminium could be obtained electrolytically, and of Frasch, who saw in the oil and salt wells the suggestion of the possibility of recovering sulphur from the bowels of the earth, and of Gayley, who saw the possibility of the dry blast in increasing the output and decreasing the cost of the blast furnace—and tonight, in the case of Hyatt, who saw in the drop of dried collodion the possibility of producing a plastic mass, which was finally obtained in celluloid.

"It was Tyndall who emphasized the extreme value of the two little words 'as if' when used by the scientific mind, showing how, from things seen, a scientific imagination can lay bare things unseen and make possible discoveries of great value. Discoveries often come by accident, but it is the imaginative mind that sees in these discoveries future possibilities. It is the imaginative mind which, following out discoveries so made, is led into unlimited fields of usefulness. We must not think, however, of imagination as being

the sole factor, although it is probably the principal factor, in the production of valuable works. There must be energy, concentration and persistence, which will carry such a mind across the Jordan into the promised land. Nevertheless, the imagination is the most important factor here, because, without it, there would be no promised land.

"As we look around about us upon those with whom we are intimate, we see this imaginative faculty in all degrees of development, and I have this work of suggestion to offer: Those of us here who are educators, in whose hands are being moulded the minds of future chemists, should we not ask them whether the work which they are doing tends to develop this imaginative faculty, or whether it is indeed possible for them to sow in the minds of their students the seeds of imagination if they do not already exist there?

"It seems to me that there is no better place, no better occasion, than this place and this occasion, when we are honoring, by the presentation of the Perkin medal, a man in whom the imaginative faculty was highly developed, to put before you the need of the imaginative faculty in as emphatic a manner as possible and to urge that in our educational institutions this faculty should be developed to the highest degree, for,



JOHN WESLEY HYATT

if we are honoring Mr. Hyatt on account of his possession of this faculty, should we not seek to increase the number of those who possess the faculty in a high degree? Is not the real purpose of the Perkin medal something more than the honoring of its recipients—great as that purpose is—is it not for the purpose of encouraging those faculties on which the presentation of this medal rests?"

#### Presentation Speech by Dr. Chandler

Professor Chandler in his official presentation speech first gave a brief account of Mr. Hyatt's early life.

"Mr. Hyatt was born at Starkey, Yates County, New York, in November, 1837. He was educated in the public school and later in the Eddytown Seminary, where he excelled in mathematics.

"In his early boyhood he acquired a strong taste for mechanical affairs in his father's blacksmith shop. In his sixteenth year he went to Illinois and learned the printing business, working at this trade for the following ten years. . . .

"He then went to Albany and worked as a journeyman printer for about two years. Seeing a \$10,000 offer for a substitute for ivory for billiard balls by Phelan & Collander, of New York, he began experimenting nights and Sundays in the hope of gaining the reward. He made a number of useful plastic compositions, none of them, however, good enough for billiard balls, but he started to make checkers and dominos of pressed wood, and with his two brothers established what is now the Embossing Company, of Albany, N. Y., which has been a highly successful concern for more than 40 years, under the mechanical management of Mr. Hyatt's younger brother, C. M. Hyatt.

"In 1870 he invented and patented a machine for turning billiard balls, by which an unskilled workman can do as much as a dozen skilled workmen could accomplish by former methods, securing at the same time perfect accuracy.

#### THE INVENTION OF CELLULOID

"His attention having been called to the character of the solid nitrocellulose left by the evaporation of liquid collodion or artificial skin, as it was called when collodion was first put upon the market for covering cuts and other wounds, he turned his attention to the subject of nitrocellulose as a suitable material for producing plastics. It should be remembered that gun cotton, or nitrocellulose, was first discovered by Schoenbein in 1845. In 1847 Maynard announced the discovery that while nitrocellulose is not soluble either in alcohol or ether alone, it is soluble in a mixture of the two, and he gave the name collodion to the solution, which has since found its way very extensively into medical use. It also served to solve the problem of producing photographic pictures, either positives or negatives, upon glass, practically sounding a death knell for the beautiful though troublesome daguerreotype process. The wet collodion process was introduced by Scott Archer in 1851.

"Hyatt was entirely ignorant of the various efforts which had been made by Parks, Spill and others to utilize soluble nitrocellulose or pyroxyline for the manufacture of plastic materials, and consequently he started out without any hints or suggestions as to how he should proceed. His first success resulted in the manufacture of billiard balls by first making a solid core of another plastic material and covering the same with nitrocellulose dissolved usually in ether and alcohol. The process was so successful that a good business was established in 1870.

"In the meantime Hyatt invented celluloid and began the manufacture of celluloid and bone dust billiard and pool balls. At this time his brother, Isaiah S. Hyatt, joined him, and they worked together until the brother died in March, 1885.

"I do not propose to give a detailed history of the progress made by Mr. Hyatt and his brother in establishing the celluloid industry. I will merely remark that Hyatt's patent 88,633, dated April 6, 1869, was for a molding composition to imitate ivory and other substances composed of fibrous material and gum shellac or other solid fusible adhesive gum.

"His patent No. 88,634, dated April 6, 1869, was for an improved method of coating billiard balls, consisting in dipping the billiard balls made of some suitable composition into a solution of collodion which might be given any desired color beforehand.

"His patent 89,582, dated May 4, 1869, was for a composition consisting of ivory dust or its equivalent mixed with collodion and subjected to pressure during the evaporation of the solvent.

"His patent 91,341, dated June 15, 1869, taken out by the two brothers jointly, was for manufacturing solid collodion with very small quantities of the solvent dissolving the pyroxyline under heavy pressure, thus securing great economy of solvents and a saving of time.

"Their patent 105,338, dated July 12, 1870, shows the fundamental invention of celluloid. It is entitled Improvement in Treating and Molding Pyroxyline. The three claims of the original patent are:

"1. Grinding pyroxyline into a pulp, as and for the purpose described.

"2. The use of finely comminuted camphor-gum mixed with pyroxyline pulp, and rendered a solvent thereof by the application of heat, substantially as described.

"3. In conjunction with such use of camphor-gum, the employment of pressure, and continuing the same until the mold and contents are cooled, substantially as described.

"This patent was reissued three times in order to avoid ambiguities. The claims of the last reissue are as follows:

"1. The use of finely comminuted camphor-gum mixed with pyroxyline pulp, and rendered a solvent thereof by the application of heat, substantially as described.

"2. In conjunction with such use of camphor-gum, the employment of pressure, and continuing the same until the mold and contents are cooled, substantially as described.

"The specification fixes the proportion of about 1 part of camphor to 2 parts of pyroxyline. Modifications of this process were embodied later in U. S. patents 156,352 and 156,353.

"From this time on celluloid became a most important plastic, superior in almost every respect to any other plastic hitherto proposed, for the manufacture of the greatest variety of articles useful and ornamental.

"Seventy-five different patents were taken out either by John Wesley Hyatt alone or in association with his brother, Isaiah S. Hyatt, and an enormous establishment grew up at Newark in the hands of the Celluloid Company."

Professor Chandler then mentioned that in one of the most important and recent works on applied chemistry he found the statement that celluloid "was first produced by Daniel Spill, of Hackney, England, and came into commerce under the name of xylonite. Spill's method of converting the nitrocellulose has been followed for more than forty years."



Professor Chandler emphasized that there was no logical ground for making that statement. Celluloid was invented by the brothers Hyatt and not by anyone else.

It is quite true that many other experimenters sought to prepare useful plastic compounds with the aid of pyroxyline prior to the Hyatt invention of celluloid. But no one succeeded in producing anything like celluloid. Professor Chandler proved his point by a careful and detailed analysis of the patents of Alexander Parks and Daniell Spill, and showed that Spill, in his British patent 1739 of May 11, 1875 (nearly five years after Hyatt's collodion patent) made no reference to any material that could possibly be called celluloid. This whole matter has been threshed out in the Federal courts as long ago as 1886, and the Hyatt patents have been sustained, although everything that had been patented or published was carefully studied and discussed during the litigation.

#### OTHER INVENTIONS

"Mr. Hyatt's activities were not limited to celluloid. Among his other inventions also of great importance we find a *sugar cane mill*, very superior to any mill previously used in its efficiency, both in increasing the percentage of juice extracted from the cane and greatly diminishing the time necessary to extract it, and giving a higher value to the refuse bagasse as fuel.

"In the early 80's Mr. Hyatt and his brother Isaiah took up the subject of *water filtration* and started a company called the Hyatt Pure Water Company. Isaiah Hyatt invented and patented a very important feature of the filtration process February 19, 1884, Patent 293,740. It marks the beginning of a new era in water purification. Coagulants had been previously used to purify water, but the difficulty was that the water was held in large tanks or cisterns. The coagulant was added to it, the whole was thoroughly agitated and then it was necessary to allow it to stand 12 to 24 hours for the coagulum to settle to the bottom. The Hyatts conceived the idea of employing a coagulant which could be added to the water while it is on the way to the filter, so that no large settling tanks or basins are required and no time is lost. The claim of this patent is as follows:

"The method herein described of arresting and removing the impurities from water during an uninterrupted passage of the same from a supply pipe into a filtering apparatus, thence through a filter bed contained therein and out through a delivery pipe leading therefrom, which method consists in introducing into the water simultaneously with its passage to or into the filter a substance which will sufficiently coagulate or separate the impurities to facilitate their arrest and removal by the filter bed, thus obviating the necessity of employing settling basins.

"I was connected with a litigation which followed the issue of this patent, and studied the process and apparatus at Somerville, N. J., Niagara Falls and Elmira. The process was unusually successful. At Somerville the river water exhibited a milky opalescence caused by such fine particles of clay that no filter would clarify it. By a proper attachment of an alum box to the feed pipe to the filter, a minute quantity of alum was added to the stream of water on its way to the filter, less than one grain to the gallon and in the few seconds that elapsed before the water reached the filter bed of the ingeniously constructed Hyatt filter, coagulation had taken place and the coagulum, including the alumina of the alum and the clay, bacteria and other suspended impurities of the water, had been converted into such flocks as made it possible for the bed of sand in the filter to arrest it completely. These Hyatt filters are so

constructed, whether they are on a large scale or small scale, that they can be washed completely at any convenient moment by simply reversing the current through the filter. This churns up the sand and separates from it the accumulated coagulum.

"Nearly all the paper mills and woolen mills in the country were and still are supplied with these filters, as are also more than 100 cities and towns.

"The validity of the patent was established through law suits which were brought against the city of Elmira and the city of Niagara Falls. In 1891-2 Mr. Hyatt took up the subject of *antifriction roller bearings* with great success.

"I think that the facts to which I have called your attention, although very briefly expressed, will satisfy you of the great achievements of Mr. Hyatt and will fully justify your committee in placing Mr. Hyatt beside Sir William Henry Perkin and the six American chemists who have already received the Perkin medal.

"It gives me great pleasure, as the representative of the Society of Chemical Industry, and the affiliated chemical and electrochemical societies, to place in your hands, Mr. Hyatt, this beautiful token of the appreciation and affection of your fellow chemists."

#### Mr. Hyatt's Speech of Acceptance

Mr. Hyatt spoke as follows:

"I have never looked forward to any such honors as you have bestowed upon me, and I do not know how fittingly to express my gratitude. You have overlooked my lack of early training in the sciences with which you are all familiar, and only look to results which have been obtained mainly by persistent and, many times mistaken, experiments. Some successful experiments I might never have made if I had been familiar with the danger theories of some learned men.

#### THE INVENTION OF CELLULOID

"From my earliest experiments in nitrocellulose, incited by accidentally finding a dried bit of collodion the size and thickness of my thumb nail, and by my very earnest efforts to find a substitute for ivory billiard balls, it was apparent that a semi-liquid solution of nitrocellulose, three-fourths of the bulk of which was a volatile liquid while the final solid was less than one-fourth the mass of the original mixture, was far from being adapted to the manufacture of solid articles, and that I must initially produce a solid solution by mechanical means.

"The only useful solvent known to me at that time was a mixture of alcohol and sulphuric ether; with the old formula (about equal parts of ether and alcohol) I mixed in a closed mill a thick paste of soluble cotton, made by the old firm of Charles Cooper & Co. After mixing, the cover of the mill was removed and the mass evaporated down to a thick dough, which was then forced accurately around the ball (made of another substance), and allowed to dry.

"This I found resulted in a rather brittle coating, owing, as I found, to the unequal evaporation, leaving only the alcohol, a poor solvent by itself, at the final shrinkage. This was remedied by using only the least amount of alcohol (five parts ether to one alcohol) necessary as a solvent. Even this coating shrunk to less than half of its original thickness and required to be dried immersed in water under several hundred pounds' pressure per square inch to insure its solidity and freedom from bubbles. It became necessary to strain the mass by forcing it through a very fine sieve to exclude the unnitratated fibers.

"All these difficulties stood in the way of success, except in high-priced articles like billiard balls. Other seriously objectionable features became apparent. In order to secure strength and beauty only coloring pig-

ments were added, and in the least quantity; consequently a lighted cigar applied would at once result in a serious flame, and occasionally the violent contact of the balls would produce a mild explosion like a percussion guncap. We had a letter from a billiard saloon proprietor in Colorado, mentioning this fact and saying he did not care so much about it, but that instantly every man in the room pulled a gun.

"I next had a small beating engine made, to pulp the nitrocellulose. In one experiment I placed a small quantity of this dried pulp in a strong cylinder and forced quickly a minimum quantity of liquid solvent into it with high pressure. The result was a solid substance, as hard as sole-leather, which soon dried, leaving a fine hard disc about three-fourths of an inch in diameter and one-half an inch thick. While no explosion ever resulted from this, there was real danger to be feared, and the matter was dropped.

"My brother, I. S. Hyatt, joined with me at that time, and finding it stated in some patents to which I was referred, that a little camphor added to the liquid solvent was beneficial, we conceived the idea that it might be possible to mechanically mix solvents with the pulp and coloring matter while wet, then absorbing the moisture by blotting papers under pressure, and finally submitting the mass to heat and pressure.

"To our surprise, we noticed a slightly solvent action of the precipitated and washed camphor upon the pulp, even before the heat and pressure, and without other solvent we succeeded in producing a transparent slab one-fourth of an inch thick, fine, and as hard as wood.

"My brother took some samples to the American Hard Rubber Company, with the view of interesting them. They employed the late Professor Charles A. Seeley, who had made collodion for the government during the Civil War, to investigate the matter. He came to our place in Albany, N. Y., and we conducted the whole process for his inspection, very successfully. He remarked that he had come prepared to detect some chicanery, but could see no deception, and expressed himself as satisfied. He kindly advised us that if, accidentally or otherwise, we were to apply a little too high temperature, the quantity we were dealing with would inevitably destroy us with the building and adjacent property. While we did not accept this as true, it was disturbing.

"The following day between 12 and 1, when all were out, I rigged up a four-inch plank used as a vise-bench, braced it between the floor and ceiling, between the hydraulic press and the hand pump, intending it to shield me from possible harm. I then prepared the mould, heating it to about 500 degrees Fahrenheit, knowing it would certainly ignite the nitrocellulose and camphor, and would abide by the result. The gases hissed sharply out through the joints of the mold, filling the room with the pungent smoke. The mold, press, building and contents were there, including myself, very glad that I did not know as much as the professor.

"The next step was to make a small stuffing machine, consisting of a cylinder, four-inch bore, about a foot long, terminating in a tube three-fourths of an inch bore, ten inches long, immersed in an open oil-jacket, with a gasburner and thermometer. A capnut with one and one-fourth inch screw forced a plunger upon the cakes of incipient celluloid, which were heated at the outlet end of the cylinder passing through the heated tube into molds, and also through nozzles forming rods, tubes, etc.

"We found it advisable to lower the melting point of the camphor by adding a small quantity of alcohol or other solvent of camphor. A much larger hydraulic stuffing machine was then made. Dental plate blanks were the principal part of our early business.

"My brother interested some New York capitalists—principally composed of General Marshall Lefferts, Joseph Larocque and Tracey R. Edson—and we removed to Newark, N. J., in the winter of 1872-73. We had nearly all the appliances and machinery to design and build, which progressed with some halts and mistakes for two or three years, when a fire occurred in our four-story and basement building, utterly destroying all our stock and machinery, and pushing out the whole front of the building (which was very weak), and severely injuring several of our men, who all finally recovered, although one—Mr. Charles S. Lockwood—was in great danger for a long time. We then started our present works, acquiring knowledge and experience, my brother starting a separate factory for making brushes, mirrors and combs. Early in 1878 my brother went to Paris and started the French Celluloid Company.

"Before we left Albany we began the use of tissue paper in place of carded cotton or bleached flax, which finally resulted in getting tissue paper of definite thickness and materials, and breaking it up into small separate pieces by a machine I constructed, drying these separate pieces in a loose mass and nitrating them instead of the carded cotton.

"In 1876 I was allowed to employ a chemist for determining our acids and to systematize our nitration, instead of merely using hydrometers and thermometers, and Mr. Frank Vanderpoel was selected by me. So far as I know, the analyses of mixed spent acids was not reduced to practical work. Professor Seely proposed that we separate the nitric and sulphuric acids by distillation, and then bring these to the proper strength before mixing, which was not adopted. Vanderpoel first removed the gelatinous flock by adding finely powdered natural barium sulphate and allowing the barium and flock to subside, which was a great success. I had previously tried filtration, which was impractical.

"After much labor Vanderpoel perfected a quick and accurate method of determination of the spent acids, and then added the required fresh acids. An elaborate and extensive battery of tanks was constructed, the acids being moved through copper pipes, where required, by means of air pressure. The tanks for mixing the comminuted tissue paper with the prepared acids were arranged on a turntable supporting a dozen or more tanks, each holding hundreds of pounds. A rotating stirrer was arranged to stir in the requisite amount of paper in one tank, the turntable being revolved to the next tank, and so on. At a distance embracing about half a dozen tanks from the stirrer was located a centrifugal machine, which separated out most of the acids. The nitrated paper was then thrown into a washing device, and the partly washed paper then fell into large tanks of fresh water and was thoroughly washed. A very considerable number of tons of paper per day were and are treated in this way.

"The next procedure was to grind this nitrated paper in a beating engine. The water was then mainly removed by a centrifugal machine. The mixture of pigments camphor and nitrocellulose was then made, according to the results required, and ground together in a mill, then pressed into slabs or cakes, and still further deprived of moisture by great pressure, and finally deprived entirely of moisture by blotting papers repeatedly changed. These cakes are then broken up and alcohol or other desired solvents added and allowed to soak in. The partly dissolved mass is then masticated in heated rolls, turned out into necessarily rough sheets, is cut into strips and rolled up into cylinders, ready for the stuffing machine.

"The great want was to furnish celluloid in solid perfect sheets, and this neither the rolls nor the stuffing



machines could possibly do, with all our experience. I constructed a special nozzle for the stuffing machine, to form a slab about one and one-half inches thick, seven inches wide and several feet long, which was pressed between steam plates, one of them with undercut grooves, to hold the slab. A machine was made with shaving knife and reciprocating bed, and by it the slab was shaved into sheets of the desired thickness. These slabs were necessarily imperfect, and were too small. After showing this result to the other directors, I proposed building a hydraulic pressure steam-heated mold, to make a slab or block about two feet by five, and three inches thick, in which to weld and press a pile of rough sheets from the masticating rolls.

"General Lefferts, our much-beloved president, had suddenly died a year or more before. To those who knew the least about celluloid my suggestion looked pretty good, but to others came a great fear of possible danger and failure to weld up such a mass. At last they gave me authority to build the apparatus, limiting me to less than half its cost if fairly estimated. With this authority, which consisted more of the privilege of trying such an apparatus than in providing for its cost, I ordered the machine, agreeing to pay the machinist all above the appropriation if it failed to work.

"The machine was built and most carefully tried in the presence of only the new president, who knew little about celluloid, and Mr. Stevens and Mr. Lockwood among the employees. The mold was cooled and opened, and nice sheets were at once made, considering that only scrap material was used, though less than half the block was welded. This meant reheating, which was at once done, and the whole was known to be a success.

"I dwell upon this because of its vast importance to us. It multiplied the value of celluloid many times, making a much stronger and finer material than was produced by the former means.

"About this time we were enjoined from bleaching the iron out of the pulp, caused by the iron-beating knives, and it was up to me to remedy the serious difficulty. A large revolving drum of copper, through the axis of which was a shaft with beating arms rotating at a very high speed, in which the mixture of nitrated paper, camphor and pigments was placed, and the whole beaten to a pulp without the discoloration of the iron and water, and without the loss in washing and bleaching the fine pulp from the beating engine.

"In order to clearly differentiate my work in celluloid from that of others in the nitrocellulose industry, I will summarize as briefly as I can:

"First, the idea of combining with the nitrocellulose only the exact or approximate amount of solvent required for a solid solution. This required a nearly perfect mechanical mixture before very much solvent action could take place.

"Second, completing the solution by means of heat and pressure.

"Third, eliminating the practically unnitrated fibers by pulping.

"Fourth, employing tissue paper in place of carded fiber.

"Fifth, avoiding the terrible danger of drying out the moisture by exposure in drying room.

"Many years ago I patented the process of first pressing out all the water possible and displacing the remainder by forcing alcohol through under pressure. This, I understand, is now used by other nitrocellulose workers, but we prefer the method herein described.

"Sixth, the stuffing machine process.

"Seventh, the sheeting process, most essential.

"Mr. Stevens has been with me ever since he was fourteen years old, and has invented solvents and many

other things of great importance in the art, and stands at the head of nitrocellulose workers at the present time.

"Mr. Harrison, in his department, has invented the method of imitating the grain of ivory, of smoked pearl, of onyx, and of many other beautiful colors and effects. He has been with us nearly forty years. Others are entitled to much credit, but it is impossible to name them here."

Mr. Hyatt then gave a description of his sugar-cane mill, an account of which is reserved for a later issue. Mr. Hyatt concluded as follows:\*

"I have taken out 238 patents (a few of them being joint inventions with others), and several new industries have resulted. The one of next importance to celluloid is named The Hyatt Roller Bearing Co. I have received considerable liquid money, most of it having been of a volatile and inflammable nature. Age ought to bring wisdom."

#### Dr. Vanderpoel's Reminiscences

Dr. Frank Vanderpoel began his remarks with a personal tribute of affection to Dr. Chandler and Mr. Hyatt. He became Mr. Hyatt's chemist three years after he had left Columbia University.

"To refer to the early days of the celluloid business in Newark, there seemed to be a good deal of prejudice against it in that city. On account of an unfortunate fire which took place there shortly after the company began operations, the people of Newark did not, as a rule, take kindly to a material which was reported as being made of gun-cotton and camphor. Of course, a statement like this would never lose in transmission, and the public would look askance at any article of commerce which contained as an ingredient this high explosive. I remember a story told of a man who happened to touch, with a lighted match, one of a pair of cuffs made of celluloid when, to his amazement there was a terrible explosion, and he barely escaped with his life—or words to that effect.

"Well, this and other stories of a like nature produced a strong feeling against the manufacture of this new substance, to say nothing of its use by the public and, of course, some one had to bear the brunt of it. Naturally, the inventors (the Hyatt brothers) and those most intimately associated with them in business, had to carry the burden; and it wasn't a very light one either. But our friend had the enthusiasm of the inventor, an enthusiasm which he imparted to those who were associated with him, and without which success would have been long delayed, if not impossible.

"I suppose that, in the minds of some, even at the present day, the idea exists that the principal ingredient in the material referred to is true gun-cotton, the highly nitrated compound of cellulose. This is because the public, as a rule, is not given to distinguishing between the compositions of different chemical compounds. If, in order to make true gun-cotton, you treat cotton fibre with a bath composed of a mixture of strong sulphuric and nitric acids, why, it stands to reason—so some of these people think—that cotton fibre treated with a bath of these same acids, no matter what their percentage composition may be, will be converted into the explosive compound. You know that this is not the case, but the general public does not, or did not, some thirty years ago.

"Shortly after I became associated with the celluloid company, samples were made of these two varieties in nitro-cellulose, using raw cotton fibre in each case, and

\*Mr. Hyatt told informally a little story which, while not included in his official address, is too characteristic to omit it from this report. An employee of his of many years—a foreigner who had never learned to talk correct United States, in spite of his other abilities—came to die. Said he: "Me now die. John Hyatt die some day too. Perhaps me go hell. Me don't care. John Hyatt build ice machine."

their solubility tested in a strong solvent, and thus compared. Any nitro-cellulose which would not dissolve in this solvent would be utterly worthless as a basis for the manufacture of our product.

"Upon making the test, the fibres of the lower nitrated compound disappeared in the solution upon the instant that they touched the solvent. This was the variety of the nitro-cellulose which was the principal ingredient in the manufacture of celluloid. How long do you suppose it took the other, the true gun-cotton or tri-nitro-cellulose (or, as some call it, hexa-nitro-cellulose) to dissolve? It was kept in the bottle of solvent for more than six years without showing the slightest evidence of a solvent action—each fibre standing up bravely—then it was thrown away. But the public didn't know of this difference and thought that the product of our friend's brain was a menace to every one who came near it. Prejudice will go a great way, and it takes courage and pluck to fight it.

"Mr. Hyatt's share in the work of making celluloid did not consist in merely getting out the various patents and handing them over to the company. He was often at the works, superintending, advising, assisting in the manufacture, and always on call if things needed his attention. We all felt confidence in his judgment and found afterwards that this confidence was not misplaced.

"The inventor's enthusiasm is a valuable asset or adjunct in the matter of bolstering up the faint-hearted employee who may sometimes think that he has an idea of his own which he would like to have exploited. I think that more than one of the men employed at the works received encouragement from our friend, Mr. Hyatt, in certain lines of work in which they were engaged and which they might have been inclined to give up if it had not been for his enthusiasm and optimism. It not infrequently happens, in this world, that the success which a naturally timid person achieves is due, in some degree, to the encouragement which he may receive from one who has more courage and backbone. As the boys would say, "He doesn't get cold feet," and this means the difference between success and failure. We sometimes need optimistic friends who will help us over the rough places, or the thin ice—put it whichever way you will. Mr. Hyatt was one of these.

"This comforting way of looking at things does not mean, let me say, that everything that a fellow would think of, and suggest, would be endorsed by him. I well remember a remark made by him one day when he had occasion to relate how a certain so-called or self-styled chemist had utterly failed in the solution of a problem which he was absolutely certain he could solve. In fact, he claimed to have solved it some time before, but when a second attempt was made, the result was not in the least satisfactory. "Yes," said Mr. Hyatt, "A man may say to you, 'if I put this brick which I have here on this side of the street with that one over across the way, I'll have two bricks'; but when he goes across the street he finds what he saw on the other side was not a brick, after all!"

"Very likely Mr. Hyatt does not remember this occurrence, but I assure you it is true as is also another one which happened at the works and illustrated his practical way of looking at things.

"You know it is just as important, sometimes to know what to omit doing as to know what to do; what to leave out of your invention as well as what to put into it. A mutual acquaintance, an employee of one of the branches of the celluloid company, went to our friend one day and told him of an invention which he had almost worked out in his mind, and asked his opinion of its value. He was going to make billiard balls out of celluloid, these balls to have a hollow center,

and this small cavity was to be partly filled with mercury which, when the ball was struck, would act as a sort of break on the motion of the ball, and cause it to slow down. Mr. Hyatt's reply was, 'Well, if billiard balls came ready-made and partly filled with mercury as you suggest, and you could find some way of getting that mercury out, I think it would be a fine thing.'

"There was one element in our friend's makeup concerning which I cannot speak too highly, for the reason that you don't find it anywhere. In fact, I believe it to be the exception and not the rule. It was his willingness to give every one credit for his own idea and not attempt to appropriate it himself. Sometimes he went further than this; he would take the thought that you gave him, enlarge upon it, or improve it, and then hand it back to you as your own. How many do that today? I think that if you counted them on your fingers, you'd have some fingers left over when you had gotten through counting. . . . There is another quality or characteristic possessed by the successful inventor which is a most important asset. Something which happened not very long ago on a train running across the Arizona desert may, in a slight degree, illustrate the point. The day was hot and dusty, and anybody who has ever traveled those alkali deserts with nothing much in the way of vegetation but sage brush in sight, can tell you what that means. It is decidedly uncomfortable, to say the least, and you look in vain for a cool spot where your eyes may rest—a clump of trees, or a little running water.

"One of the passengers kept looking out of the window every minute or two, pulling the shade to one side as he did so, and then letting it drop back again into place. Another passenger, noticing the interested look on his face asked him what he saw. 'I see miles and miles of corn, acres of wheat and cotton and the whole country covered with farms,' he said. 'When the supply of water back of the tops of those mountains is tapped and brought down here to this prairie, we shall have it blossoming as the rose.' What is your name, the other passenger asked. 'Luther Burbank,' was the reply.

"Now what shall we call this quality or element in the composition of the successful inventor and advanced thinker along these lines? Some might say, 'efficiency.' Well, that is a good name for it. It means making two, three or twenty corn stalks grow where none, or at the most, only one grew before. It means causing the dry desert to become a veritable garden. It means taking a product of the laboratory which before had been only a chemical curiosity, and working upon it in such a fashion, and with such determination that it shall become a most useful article of commerce which shall find application in a multitude of ways and bring comfort, yes, and happiness to many a home."

**Gold in Canal Zone streams** has been investigated by the official geologist for the Isthmian Canal Commission, who reports that in no instance has the metal been found in quantities that would justify its recovery. Many samples were washed, yielding from a color or two up to 2½ cents per cubic yard.

**Dressing Copper Plates.**—A correspondent of the *South African Mining Journal* states that he has found a simple remedy for discoloration and greasy scum on amalgamating plates. In the dressing process he has discarded brushes and adopted chamois leather or Hessian sacking. In his opinion the brushes merely mix the scum with the amalgam, while the leather or sacking actually removes it. Since the adoption of this process the plates in the correspondent's mill are in excellent shape.



## Synopsis of Recent Chemical and Metallurgical Literature

### Gold and Silver

**Volatilization of Metals as Chlorides.**—In our issues for April and May, 1913, pages 220 and 230 respectively, mention was made of the process of treating sulphide ores with salt and volatilizing metal chlorides at a high temperature. This process was brought out originally by Pohle and Croasdale in the United States fifteen years ago, but was again discovered last year

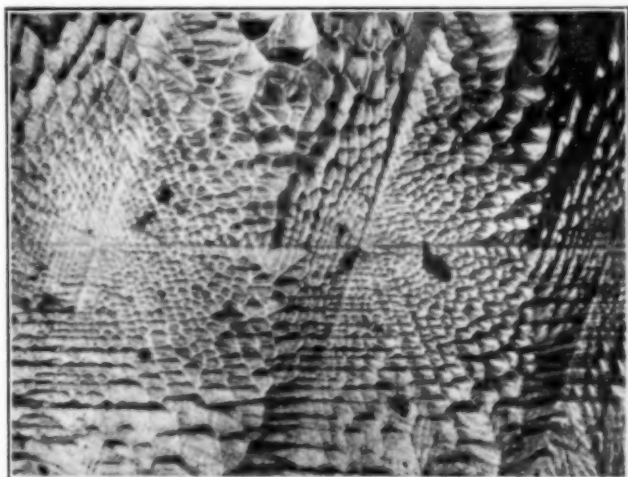


FIG. 1—PURE SILVER

by Mr. Ben Howe, of Australia. In the issue of the *Mining Magazine* for December, 1913, Mr. Howe gives personally the results of his original investigations and the later tests which he made on a large scale at the Gwalia Consolidated mine in Western Australia. His work came to an unsuccessful end mainly, as he believes, because of unfavorable financial and local conditions; but it is interesting to note that he encountered the same difficulties that Pohle and Croasdale were unable to overcome years ago. In fact, Mr. Howe has stopped just where the earlier investigators left the process; and it is unfortunate that he could not have known of their work so that he could have conserved his funds and started with full knowledge of previous experience.

The ore at the Gwalia Consolidated contains gold to the value of \$9 or \$10 per ton. Conditions of mining are favorable, but the metallurgy is difficult. The ore is a silicate of alumina, with quartz and calcite, containing sulphides of iron, arsenic and antimony. The mineral is finely disseminated through the gangue, and consequently mechanical concentration has proved a failure. Cyanidation after roasting yields only 75% recovery. Mr. Howe turned his attention to volatilization as a possible means of treatment, and met with some degree of success. In brief, the process consists in mixing the ore with salt, roasting at a temperature of about 1000 deg. C., volatilizing the gold as chloride, and recovering it in settling chambers and solutions as an amorphous powder.

Mr. Howe's difficulty centered in the absorption or condensation problem, and it is probable that he would have been impressed with this more quickly had he been trying to volatilize and condense chlorides of base metals such as copper. Having only gold in his ore, the problem was simpler. After allowing the fume to condense in chambers by reducing the velocity of the gases by expansion, and by providing baffles in the form of rods or wires such as are used in smelting works in

this country, the gas was drawn through a series of absorption boxes by means of a vacuum pump giving a vacuum of from 1½ to 4 in. mercury. The vacuum boxes were arranged like zinc boxes in cyanide precipitation, and were filled with broken quartz for the purpose of breaking up the bubbles and exposing a large surface to the water. In a test run lasting 83 hr. Mr. Howe volatilized 92 per cent of the gold and recovered 85.7 per cent.

It was found that a long revolving furnace was best adapted to the work, and that the volatilizing process had been carried on most successfully when the discharged tailing appeared in the form of small fritted balls of gangue. Mr. Howe still has faith in the value of the process in treating certain refractory ores, and believes that the difficulties encountered can be overcome.

**Detection of Platinum Metals in Gold-Silver Cupellation Beads.**—It is well known that the presence of small amounts of the platinum group of metals in gold and silver beads obtained from cupellation causes a crystallization or frosting visible to the naked eye. It has been found, however, by Messrs. C. O. Bannister and G. Patchin that for beads containing less than 1.6 per cent of platinum it is necessary to use the microscope to detect the characteristic appearance of beads containing this metal. Their results, with many microphotographs, are published in *Bulletin No. 111* of the Inst. of Min. & Met. Four of the microphotographs are reproduced herewith, being Figs. 1, 2, 3 and 4.

The summary of results and conclusions arrived at by the authors is as follows:

1. The microstructure of silver, gold and silver-gold cupellation beads is described and illustrated, and in the silver-gold beads the crystallization of silver and gold is distinctly traced in the structure. The visual appearance of beads composed of equal amounts of gold and silver is shown to be similar to that of beads containing over 1.6 per cent of platinum.

2. It is shown to be possible by simple microscopic examination to detect platinum in cupellation beads



FIG. 2—SILVER (0.4% PLATINUM)

when present below 1.6 per cent.—that is to say, when present below the amount necessary to cause crystallization visible to the naked eye.

3. The presence of iridium in small quantities can be detected in silver beads by the strained appearance of the crystal caused by internal stresses.

4. The presence of traces of rhodium may be detected by a crystallization of the beads in which the facets of the crystals are distinctly visible. When over 0.03 per cent of rhodium is present this is indi-

cated by a bluish-gray color and a large amount of spitting.

5. Ruthenium is indicated in cupellation beads by a black crystalline deposit firmly attached to the bottom edge of the beads, and in the experiments carried out was always associated with a herringbone-like structure when examined by the microscope.

6. Palladium causes a structure similar to that found in the presence of platinum, but yields satis-

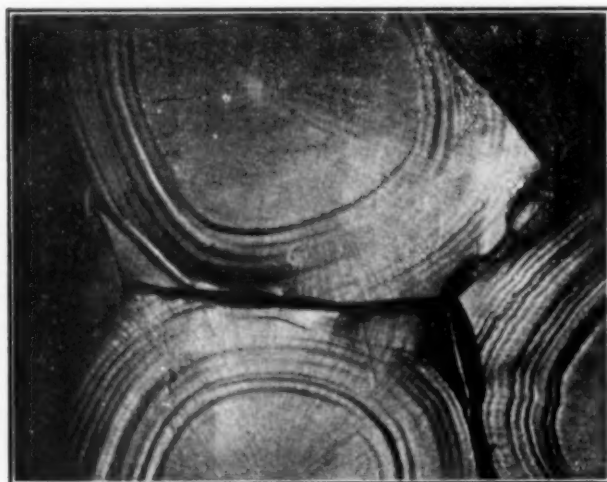


FIG. 3—PURE GOLD

factory evidence of its presence by coloration of the parting acid.

7. No specific indications of the presence of osmium are afforded by the tests made.

8. The indications in the presence of iridium are found to apply equally well to osmiridium.

#### Copper, Zinc and Tin

**Monolithic Magnetite Linings for Basic Copper Converters.**—Within the past few years the practice of converting copper matte in converters lined with magnesite brick has become almost universal and has practically displaced acid converting. The usual practice is to line a shell with magnesite brick varying from 9 to 30 in. in thickness in different parts of the shell, according to the severity of the chemical action. Sooner or later the lining spawls and cracks, owing to variations in temperature, and the lining must be renewed. The artificial production of a monolithic magnetite lining or coating over the magnesite brick is the subject of a patent granted to Messrs. A. E. Wheeler and M. W. Krecji, and of an article by them in the December *Bulletin* of the A. I. M. E.

This method of protecting a lining is based on the fact that magnetite is formed in artificial magmas, especially when the proportion of silica is low. Any excess iron over that required to combine with the silica is likely to be deposited in the form of magnetite. As the melting point of magnetite is probably not less than 1527 deg. C., and the temperature of the converter rarely goes over 1200 deg. C., it is evident that the lining of magnetite would have a higher melting point than the converter contents. The lining can be formed by blowing 35 per cent. matte for 10 or 15 minutes and then allowing the charge to cool by the addition of more matter. Alternate blowing and cooling, with the addition of more matte, is continued until the charge is blown to white metal. As no silica is added during this operation, magnetite is formed, and it can be observed as a coating over the magnesite lining. After this the converting operation, with added silica, can proceed as usual. The lining can be renewed

at will by blowing matte without silica, and its thickness can be regulated by blowing with more or less silica. Under these conditions the lining should last a very long time, and should be of material value in protecting the magnesite bricks and in prolonging the life of the converter. Greater duty per lining obtained by this practice is ascribed by the authors to the protecting magnetite.

**Zinc Determination at Broken Hill.**—In our last issue, page 54, we gave a synopsis of the method for determining lead as adopted by a sub-committee of the Australasian Institute of Mining Engineers, and published in the *Proceedings* of that society, No. 10, 1913. The method for zinc adopted by the same committee is given herewith.

The committee considered only two methods, viz., titration of the zinc with potassium ferrocyanide, (1) in acid solution, and (2) in alkaline solution. Interfering elements in both processes are cadmium, copper, nickel, cobalt, manganese, iron and aluminium, and these must be separated before titration. Two modifications of the second method are given, consisting respectively in one and two precipitations of iron and manganese.

The titration in acid solution is well known in this country, and is considered standard. Opinions will be found to differ among our chemists as to the value of re-solution and precipitation of the iron and manganese. The Australian chemists, however, have adopted the titration in alkaline solution, with two treatments of the iron-manganese residue.

#### Solutions Required

**Potassium Ferrocyanide.**—32.5 grams of the pure salt are dissolved in one litre of distilled water.

**Ferric Chloride and Potassium Tartrate Emulsion.**—200 grams cream of tartar and 2 cc. neutral ferric chloride solution containing 10 per cent iron are added to one litre of water. The emulsion must be well shaken before using.

**Outside Indicator.**—Pure glacial acetic acid, 99-100 per cent.

Pure metallic zinc or zinc oxide may be used for standardizing, but the latter should be ignited first to



FIG. 4—GOLD (0.5% PLATINUM)

about 600 deg. C. and cooled in a dessicator. In the case of zinc weigh two lots of 0.25 gram and 0.1 gram, or of zinc oxide 0.3 and 0.1 gram, and dissolve in 5 cc. dilute  $\text{HNO}_3$  (1.4). Evaporate gently until nearly dry and dilute with 100 cc. hot water. Add 7 grams  $\text{NH}_4\text{Cl}$  and 8 cc. ammonia, make up to 300 cc. with hot 1 per cent  $\text{NH}_4\text{Cl}$  solution, add 30 cc. tartrate emulsion, and titrate with ferrocyanide solution until



one drop added to a drop of glacial acetic acid gives a faint blue color. The standard and blank are calculated as explained for lead. (See January 1914 issue, p. 54.)

For sulphide ores weigh out 0.5, 1 or 2 grams, depending on the grade of the ore. No titration should require more than 25 cc. of the standard solution. Add 10 cc.  $\text{HNO}_3$  and warm gently until decomposition is complete. Add 1 gram pulverized potassium chlorate and evaporate to dryness, avoiding overheating. For oxidized ores weigh similar quantities and treat first with 10 cc.  $\text{HCl}$  and evaporate nearly to dryness. Then add 10 cc.  $\text{HNO}_3$ , boil until all the  $\text{HCl}$  is decomposed, add the  $\text{KClO}_3$  and proceed as above.

Treat the dry residue with 100 cc. water, 7 grams  $\text{NH}_4\text{Cl}$ , 15cc.  $\text{NH}_4\text{OH}$ , about  $\frac{1}{2}$  gram sodium peroxide, and boil for about 2 minutes. Allow to settle and then filter, washing two or three times with boiling 1 per cent solution  $\text{NH}_4\text{Cl}$ . Re-dissolve the precipitate in  $\text{HCl}$ , and reprecipitate the iron and manganese with 15 cc.  $\text{NH}_4\text{OH}$  and 2 to 5 grams sodium peroxide. Boil for a few minutes, filter and wash as before. Heat the zinc solution to 70 deg. C., add 30 cc. tartrate emulsion titrate as directed above. If copper is present it is precipitated with granulated lead, the solution decanted and washed from the lead, treated with 30 cc. emulsion and 8 cc.  $\text{NH}_4\text{OH}$  and titrated as before.

With very low grade ores the amount of ammonia may prevent precipitation of the zinc, and in such cases the solution must be treated with acetic acid until a precipitate begins to form, when the titration may be completed. The solution must not become acid.

The use of a small amount of sodium peroxide in the first precipitation is advantageous in two ways—it insures complete precipitation of the manganese and prevents bumping on boiling. The acetic acid used as indicator must be 99-100 per cent strong.

## Recent Chemical and Metallurgical Patents

### Iron and Steel

**Utilizing Blast-Furnace Flue-Dust.**—The incorporation of blast-furnace flue-dust in molten iron flowing from a furnace is suggested in a patent granted to Mr. Ralph Baggaley, of Pittsburgh, Pa. The process is similar to one patented by the same inventor in connection with copper smelting, in which it is proposed to incorporate flue-dust with molten matte before sending the latter to the converter. The inventor claims that his proposed method will be more simple than briquetting or bonding, and will obviate the difficulties encountered in those processes. He uses preferably a bath of molten iron as it comes from the furnace, and mingles with it the dry material to a point short of solidification. The mixture is then cast or taken in molten condition to Bessemer converters, open-hearth or electric furnaces where the refining stage is practiced. In carrying out the process, the heavy molten pig-iron is allowed to fall from four to six feet, or such a distance as will create a suitable vortex in the mixing vessel. The flue-dust is then discharged continuously at a point within the vortex and thus incorporated with the molten mass. It is not recommended that this process be used when the furnace is producing iron intended for re-melting in a foundry, but rather when the furnace product is to be refined. (1,081,921, Dec. 16, 1913.)

**Nodulizing Fine Ore.**—In order to prevent the formation of rings of sintered material in nodulizing kilns, Mr. Lewis P. Ross, of Standish, N. Y., has patented a form of rotary kiln with cooling means so arranged that there are sections of low temperature in the walls of the kiln. This results in zones in which no

adhesion occurs, between which the adhering material accumulates in separate sections. The latter ultimately fall of their own weight due to the lack of support. (1,081,063, Dec. 9, 1913.)

### Copper and Zinc

**Apparatus for Ammonia Process.**—In Fig. 1 is shown apparatus forming a part of an extraction plant for the recovery of zinc and copper from ores by means of ammonia. It is the invention of Mr. S. E. Bretherton, of Berkeley, Calif., who has been investigating the amenability of certain base ores to this process.

Two agitators A, A' of like construction are arranged preferably close to each other as shown. From the apexes of the cone bottom pipes C, C' are connected by branches D, D' with the discharge pipe E of a pump F, the latter being driven by a motor G. The inlet pipe H of the pump F is connected by branch I with various tanks (not shown) for pumping solutions needed in the process. From the branch pipes D, D' extend pipes J, J' which enter the agitators and terminate at the lower end of the agitating tubes K, K'. The pipe H

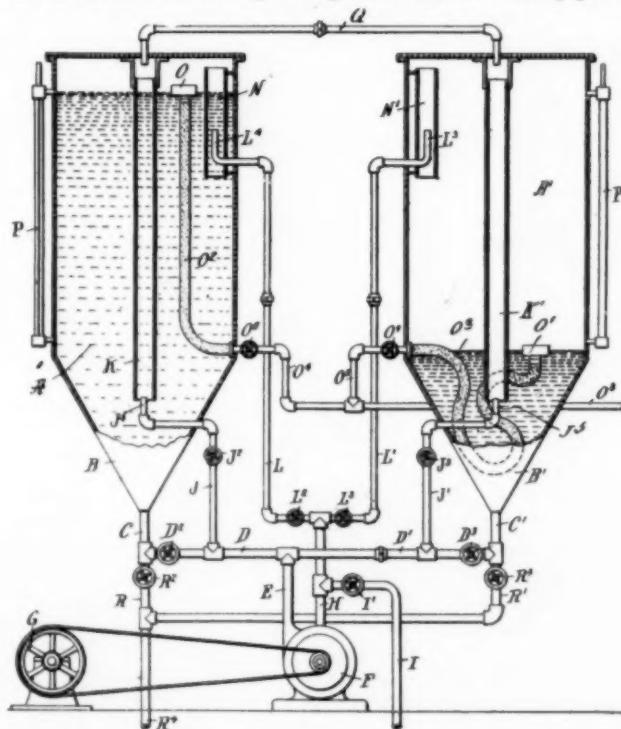


FIG. 1—AGITATORS FOR TREATMENT OF ORE BY AMMONIA PROCESS

also has connections L, L' extending into the settling tubes N, N'. Decanters O, O' are connected by flexible tubes with pipes O' and O' which lead to pipe O' that is connected with a sump for receiving solution decanted from the agitators. Gages P, P' are arranged on the sides of the agitators to show the height of pulp in each. The closed tops of the agitators are connected with each other by pipe Q for conducting gases back and forth during decantation and filling of the agitators. Means for discharging treated pulp from the agitators is provided in the pipes R, R' leading to R'. The discharged pulp may be conducted to filter press or leaching tanks for the extraction of contained gold and silver.

The cycle of operations is as follows: 1, filling A (decanting wash A'); 2, agitating A (removing residue A'); 3, decanting A (filling A'); 4, rest (agitating A'); 5, filling wash A (decanting A'); 6, agitating wash A (rest); 7, decanting wash A (filling wash A'); 8, removing residue A (agitating wash A'). It is to be

understood, of course, that the necessary valves are operated in connection with these operations. Agitation consists in circulating the contents of an agitator. The decanted solution is run to suitable precipitating apparatus. In the operation described it will be seen that decantation is effected without the admission of atmospheric air, since the gas contained in either agitator may flow into the other during decantation, and back again during filling with a new charge. Thus the dilution of the gas is prevented and impairment of the decanting process avoided. (1,082,797, Dec. 30, 1913.)

**Collecting Zinc Oxide Fume.**—As a substitute for canvas bags in the collection of zinc oxide, Mr. Morley P. Reynolds, of Cleveland, O., has patented a special form of apparatus with mechanical means for scraping the oxide from the collecting medium. The collector comprises two vertical cylindrical bags of wire cloth, supported concentrically, with an appreciable space between them. The wire fabric is strengthened and supported by T-bars attached exteriorly and running vertically. Suitable sheet metal covers close the tops of the bags. A vertical shaft extends centrally through the bags and is connected with a source of power at its

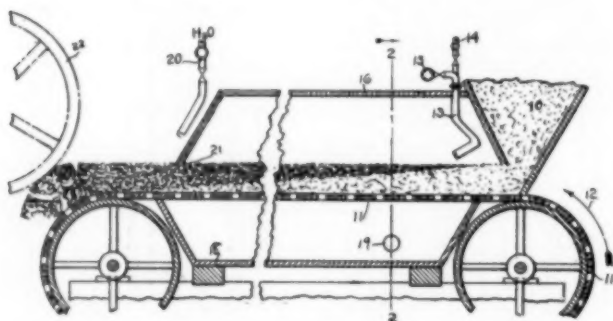


FIG. 2—HALL PROCESS FOR ELIMINATING SULPHUR FROM ORES

upper end outside the bags, and journaled in a steadying bar below the bags. Attached to the shaft are arms carrying vertical wire brushes that may be caused to revolve against the inner surfaces of the bags and dislodge any material attached thereto. In operation the zinc oxide fume is introduced into the apparatus through a pipe at the bottom. Most of the oxide is caught on the inner bag, and such fume as passes the first bag is caught on the second. When sufficient fume has been collected, the wire brushes are put in motion to scrape the oxide from the bags and allow it to fall into a collecting receptacle which closes the bottom of the apparatus. The inventor claims that the device will be more effective than canvas bags, more convenient and less expensive. (1,082,766, Dec. 30, 1913.)

**The chloridizing roasting of ores,** such as copper, from which most of the sulphur content has been eliminated, has been carried out in various ways. Thus, after the ore has been heated to the proper temperature, salt has been added in the last stages of roasting and incorporated by rabbling. According to a patented improvement of Mr. Augustus D. Ledoux, of Summit, N. J., chloridizing can be carried on as a continuous process, dispensing with extraneous heat with the exception of such as may be needed to start chemical reaction between the ore and salt. Thereafter the process continues due to the heat generated by the chemical reaction. The operation can be carried on in a furnace of the MacDougal type. The applied heat of combustion starts chemical reaction which increases as the charge progresses through the furnace, and the process becomes continuous without further aid of heat from any extraneous source. (1,082,599, Dec. 30, 1913.)

**Hall Process of Desulphurizing Ores.**—The recovery of elemental sulphur from sulphide ores by roasting in a reducing atmosphere with admission of steam, is a process that is of interest to the copper smelter. In a patent recently issued to Mr. William A. Hall, of New York, N. Y., the inventor shows the application of his process in connection with a down-draft sintering furnace of the Dwight & Lloyd type. Fig. 2 shows such a furnace with an endless traveling grate on which an ore mixture is fed from a hopper. A combustion chamber 16 covers part of the grate surface where the reaction takes place. Immediately beneath the combustion chamber is another hood 18 provided with an outlet 19 leading to a suitable suction. Within the combustion chamber is a burner 13 adapted to use liquid or gaseous fuel. The flame is always maintained in a reducing condition. Steam is added through the pipe 15. A small stream of water may be applied to the ore as it leaves the combustion zone. The operation results in the elimination of sulphur in the elemental state, and its subsequent recovery in a suitable washer. At the same time the ore is sintered according to the process of Dwight & Lloyd. (1,083,252, Dec. 30, 1913.)

### Laboratory Apparatus

**Refractory porous articles,** such as filtering tubes, diaphragms, etc., in various shapes and for different purposes may be produced according to the specifications of a patent recently issued to Mr. Percy A. Boeck, of Worcester, Mass., and assigned by him to the Norton Company of the same place. Bauxite or other impure form of alumina, or purified alumina prepared by chemical methods, is fused in an electric furnace. This product is then crushed, forming what the inventor terms "alumina grain." The grain is then roasted to remove any trace of carbides or similar products, and mixed with a small proportion, 5 to 15 per cent, of plastic clay and sufficient water to form a thin slip. The desired article is then molded from this slip, dried at about 50 deg. C., and fired in a kiln at a temperature sufficiently high to vitrify or partly vitrify the bond. The resulting article is porous and retains in large degree the chemical inertness and refractory character of the alumina grain. (1,081,573, Dec. 16, 1913.)

**Glazed refractory articles** of the above nature, such as crucibles, combustion boats, insulators, etc., are made as described above, and then treated with a glaze compound which is the invention of Mr. Arthur T. Malm, of Worcester, Mass. Since the refractory alumina article described above has a high coefficient of expansion at temperatures below white heat, it is necessary to use a glaze of approximately the same coefficient of expansion. A porcelainic glaze of the following composition has been found satisfactory.

Feldspar .....	41.8%
Flint .....	27.3
Whiting (CaCO <sub>3</sub> ) .....	17.7
Clay .....	13.2

A lead glaze compounded as follows also has proved suitable.

Feldspar .....	26.37
Whiting (CaCO <sub>3</sub> ) .....	14.38
White Lead .....	12.37
Clay .....	12.37
Flint .....	34.51

Crucibles and other articles of laboratory use prepared in this manner are said to be more serviceable and durable than glazed porcelain which they resemble in appearance. The thermal conductivity is greater than that of porcelain, which permits of quicker and more economical heating and reduces the strain in the walls during heating and cooling. (1,081,542, Dec. 16, 1913.)



## The Parral Tank System in the Leaching of Copper Ores

In view of the wide interest attached at present to the treatment of copper ores by leaching with acids, the application of the Parral agitating tank for this purpose, is of particular interest.

The Parral tank was first used in Mexico in cyanide practice as fully described in our Vol. X, pp. 48 and 434, replacing the Pachuca tank. If we compare the Parral and Pachuca tanks the objectionable height of the Pachuca tank is avoided in the low form of the Parral. In the Pachuca tank a definite ratio of height to diameter must be preserved, while in the Parral no cognizance of this ratio need be taken.

In the Parral tank system the agitation is effected by a plurality of transfer pipes of comparatively small diameter through which the continuous transfer of the pulp from the bottom to the top of the tank is brought about by compressed air. Compressed air is admitted to the bottom of these transfer pipes through a nozzle fitted with a ball valve which automatically opens and closes as required in the jet feeding of compressed air. The discharge ends of the

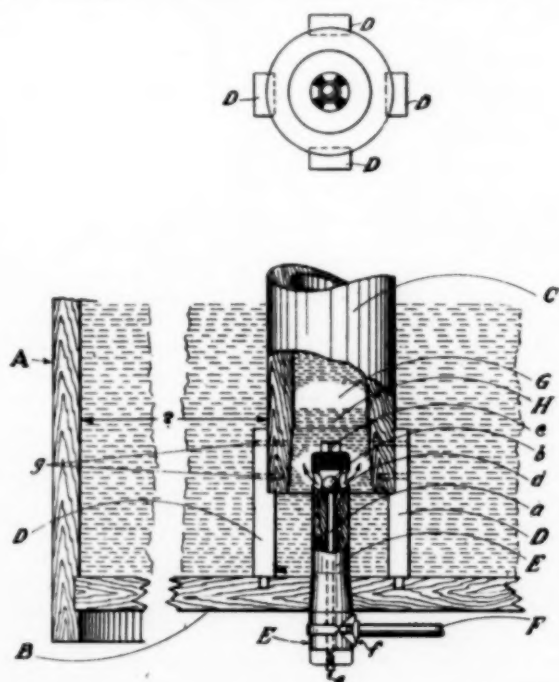


FIG. 1—AIR NOZZLE AND AGITATION PIPE FOR ACID SOLUTION

transfer pipes are horizontal and so directed that the discharging pulp will spout in the same direction with respect to the interior side of the tank and in line with segment cords thereto. This method of discharge sets up a rotary current in the tank charge which flows round and round within the tank and keeps the whole charge in rotary motion from top to bottom of tank.

If the Parral tank is to be used in copper metallurgy for the treatment of slimes and flue dust in acid solutions, the tank, the transfer-pipes, and the air-nozzle are made entirely of wood and the ball in the air-nozzle is made of glass so that all the material used is acid-proof. Fig. 1 illustrates the arrangement for acid leaching, showing a corner of the tank, one transfer-pipe, the wooden air-nozzle with the compressed air pipe attached thereto and the glass ball seated on the compressed-air axifice to prevent the entrance of the said solution when the air is off.

A are the staves of the tank side, B the bottom of the tank, C the transfer-pipe, D the wooden legs supporting the transfer-pipe, E the compressed air-nozzle inserted up through the bottom of the tank, F the wrought iron compressed-air pipe attached to the wooden nozzle by a strap flange, G the compressed-air disc in the transfer pipe, H the alternating pulp sections carried upwards between the air-discs.

The air hole bored through the nozzle is shown at a, while b is the glass ball which closes the air nozzle and prevents the entrance of the acid solution; c is the top screw plug which closes the top of the air nozzle after the ball is dropped in; the four vents through which the compressed air enters the transfer pipe are shown at d.

This apparatus can be cheaply installed in any wooden tank and, as the illustration shows, the removal and replacement of an air nozzle may be quickly and easily effected.

With this equipment the settlement of the pulp after agitation, the decantation of the pregnant solution, a second dilution of the pulp with weak solution followed by reagitation, a second settlement and decantation followed by final water-wash of the pulp may be carried on in the same tank when properly equipped for the purpose, or it may be carried on in stages in different tanks if so desired.

The patents of the Parral tank system are owned by Mr. Bernard MacDonald, 1005 Fair Oaks Avenue, South Pasadena, California.

## Personal

Mr. T. F. Bailey, president of the Electric Furnace Company of America, of Alliance, Ohio, delivered recently before the Pittsburgh Foundrymen's Association on his "electric furnace for reheating and annealing as applied to steel foundry practice."

Mr. J. M. Callow, of the General Engineering Co., Salt Lake City, Utah, is in charge of the construction of the new concentrator for the Magna Copper Co., Superior, Ariz.

Mr. Angus Cameron, president of the Radium Company of America, Sellersville, Pa., is traveling in the West and will visit the mining sections in Colorado and Utah, where his company have interests and stations, and will personally deliver parcels of radium. The policy of this company is to furnish their radium to medical practitioners in the United States.

Mr. J. E. Clennell is on the technical staff of Charles Butters, and is in charge of the new testing laboratories lately established in San Francisco.

Mr. William M. Corse, the well known secretary of the American Institute of Metals, has severed his connection with the Lumen Bearing Co. to associate himself with the Empire Smelting Co., of Depew, N. Y., in the capacity of general manager.

Mr. Louis Emanuel is superintendent of the smelter of the Arizona Consolidated Copper Co., at Humboldt, Ariz.

Mr. O. A. Enholm has severed his connection with the Electric Heating Apparatus Co., and is devoting his time to his own personal matters and experimental work.

Mr. Ernest P. Humbert, of Niagara Falls, N. Y., formerly assistant of Dr. Paul Héroult, delivered recently before the Pittsburgh Foundrymen's Association an address on "the electric steel refining furnace in the foundry."

Mr. O. C. Schaefer has been selected as operating superintendent of the mill of the National Radium Institute, now being built in Denver.

## Digest of Electrochemical U. S. Patents

PRIOR TO 1903.

*Arranged according to subject-matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

### REFINING METALS (Continued).

625,864, May 30, 1899, Emil Wohlwill, of Hamburg, Germany.

Relates to the electrodeposition of gold, and refers to his prior application which became patent 625,863. The present patent differs from that in that a part or all of the hydrochloric acid is substituted by a soluble chloride capable of forming a double salt with the gold, such as sodium chloride. The electrolysis is preferably carried at 60° to 70° C.; the quantity of chloride added is increased with lower temperatures, or with increased current density. In view of the solubility of silver chloride in sodium chloride, the latter should not exceed 100 grams per liter. In the presence of platinum and iridium, potassium chloride or ammonium chloride should not be used.

636,321, Nov. 7, 1899, Thomas Craney, of Bay City, Michigan.

Relates to the extraction and deposition of copper from large masses or boulders of native copper, such as are found in the Lake Superior District. Such masses of copper sometimes weigh from twenty-five to one hundred and fifty tons, and owing to their shape cannot be profitably mined. A suitable cavity is made in such a mass and filled with an electrolyte such as acidulated copper sulphate, the mass of copper is connected as anode, and a cathode inserted in the electrolyte. During the electrolysis, the cavity is occasionally cleaned to remove any slimes which may contain gold or silver, a fresh cathode inserted, and the operation continued.

657,119, September 4, 1900, Frank Klepetko and John T. Morrow, of Great Falls, Mont.

Relates to the deposition of copper. States that if to a solution of copper sulphate containing twelve parts by weight of sulphuric acid, fourteen parts by weight of copper sulphate, and seventy-four parts of water, about one or two per cent by weight of wood-tea is added, the deposited copper is smoother, denser, and purer; its character being materially changed and improved. The wood-tea further serves to lessen the influence of the antimony, in that the latter may be allowed to accumulate to a much larger extent without contamination of the deposited copper. The wood-tea may be prepared by soaking wood in water highly heated by steam.

669,439, March 5, 1901, Hans A. Frasch, of Hamilton, Canada.

Relates to apparatus for carrying out the process described in his copending application which became patent 669,440. The apparatus consists of a tank with a brick-lined bottom, in which are tile gratings through which the electrolyte enters. Passing through a side of the tank are a plurality of anodes of carbon, located between the tile gratings. Upon the bottom, and covering the anodes, is placed the suitably ground matte or ore containing the metal to be extracted. Above the matte is placed a layer of sand as a diaphragm. The cathodes project into the space above the sand. The electrolyte is drawn off from the upper part of the cell and circulated through the matte and in contact with the anodes.

669,440, March 5, 1901, Hans A. Frasch, of Hamilton, Canada.

Relates to extracting such metals as copper, nickel, cobalt, etc., whose hydroxids are soluble in ammonia, from their matte, ores, etc., containing them. The matte

or ore is suitably ground and spread over the bottom of a tank in contact with carbon anodes. Through the mass of matte, etc., is percolated a solution of a salt of ammonium, such as ammonium sulphate; this solution is decomposed by the electric current, the anions combining with the metal to be extracted in the matte, and forming a double salt with the excess of ammonium salt. Above the layer of matte is a diaphragm of sand, etc. Above this is a large volume of electrolyte from which the metal is deposited upon suitable cathodes. The ammonium salt electrolyte is then withdrawn and supplied to the lower layer of matte, etc. The patent contains a reference to his copending application for the apparatus which became patent 669,439.

## Book Review

**De Re Metallica.** By Georgius Agricola. Translated from the First Latin Edition of 1556, by Herbert Clark Hoover and Lou Henry Hoover. Quarto (20 x 33 cm.), 637 pages, numerous illustrations from the original. Price in America \$8, in England 25 shillings. London: The Mining Magazine. San Francisco & New York: The Mining & Scientific Press.

At the annual meeting of the Mining and Metallurgical Society of America, in New York City, January 13, the annual medal of the society was awarded to Mr. and Mrs. Hoover, in recognition of this great contribution to English metallurgical literature. This is timely and well-deserved recognition of a great literary task splendidly completed.

Heretofore this patriarch of books on mining and metallurgy has been practically inaccessible to the English technologist. We do not wish it inferred that the mining engineer or metallurgist has been thus deprived of a great technical vade mecum, but he has been cut off from a clear and highly interesting account of the beginning of modern mining and metallurgy. Just as a great picture must be viewed from one certain standpoint in order to see all its parts in their proper proportion and perspective, so the literature of mining and metallurgy focuses to the vanishing point in the book of Agricola, and needs to be viewed from this starting point in order to be seen in proper perspective. The possession of this translation completes the literature of mining and metallurgy, in English, at the beginning; the other end is perpetually being finished, up to date, but will never be completed.

To every one who knows and loves mining and metallurgy, we say "get this book, and love it more." It is like getting personally acquainted with one's ancestors. Relatively in the dark regarding the correct principles of mechanics, physics and chemistry, yet these old practitioners teach us many lessons of patience, perseverance, common sense and skillful adaptation of means to ends. Inferior to us only in the knowledge (most of which is not to our personal credit), they were certainly our equals and often our superiors in applying what they did know to useful ends. The essentially human achievements of these old practitioners give us a fraternal feeling across the three and a half centuries which makes us proud to call ourselves their successors.

The explanatory technical notes added by the translators are simply admirable.

We wish to add our congratulations to those which are coming from all sides to the distinguished translators. Their achievement may properly be included in Fabricius's eulogy of Agricola's work: "Death comes to all, but great achievements raise a monument which shall endure until the sun grows cold."